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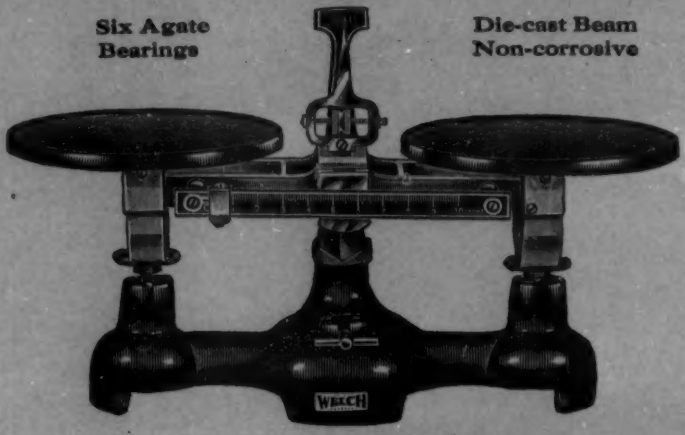

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General Science Quarterly

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Character and Value of Existing Tests, for Pupils and Teachers, in General Science[1]

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A test is a device by means of which we measure the performance of pupils. We infer a pupil's ability along any particular line after measuring his performance by means of tests. Ability, as the term will be used in this paper, means proper reaction to situations. One's ability along any line is made up of "capacity" plus training. A good test in general science, or any other subject, should possess validity, reliability, and objectivity. The test should be easy to administer and score and, if the performance of one group is to be compared with the performance of another group upon the same test, it is desirable that norms be established.

For the purposes of this discussion, we shall classify the existing tests in general science in the following manner: (1) Tests to measure the performance of pupils from which performance we are able to infer the degree to which the outcomes set up in the typical general science course have been attained; (2) Tests to measure the performance of pupils from which performance we may infer the degree of attainment of the outcomes set up in a specific general science course; (3) Tests to measure the performance of pupils from which performance we are able to infer the pupils' ability to employ the various elements of scientific thinking and to throw the necessary safeguards around each step of the process; (4) Tests to measure the performance of pupils from which we are able to infer their ability to use successfully the various study skills that are necessary in the successful study of general science; (5) Tests to measure the per-

1 Paper given at the annual meeting of the Central Association, Nov. 30, 1928.

TABLE 1. COMPARISON OF THE IMPORTANT FACTS CONCERNING FOUR GENERAL SCIENCE TESTS[2]

TITLE	Author	Publisher	Date	Type	Time	Norms	Objective	Reliable	No. of Items	Subject Matter Analysis			
										Biology	Chemistry	Physics	Earth Science
Ruch-Popenoe General Science Test	G. M. Ruch and H. F. Popenoe	World Book Company, New York	1923	Multiple choice Pictures and completion blanks	40 min.	Yes	Yes	.83 P. E. (score) = 4	130	30%	12%	38%	20%
Powers General Science Test	S. R. Powers	Bureau of Publications, Teachers College, Columbia University, New York	1927	Multiple choice	35 min.	Yes	Yes	.85 P. E. (sc.) = 3.8	100	34.5%	12.5%	37.5%	15.5%
Dvorak General Science Scales	August Dvorak	Public School Publishing Company, Bloomington, Illinois	1924	Multiple choice	20 min. or when all are through	Yes	Yes	P. E. (sc.) = 2	60	43%	9%	36%	12%
Downing Group Four Test	E. R. Downing	Author, University of Chicago, Chicago, Ill.	1926	True-False Vocabulary Picture 5 word		Yes	Not[3] entirely	?	104	39%	9%	25%	27%

2 See the Manual of Instructions that accompanies each of the first three tests.
Downing, E. R.—Norms of Scientific Ability and Achievement in High School. School Science and Mathematics, 26:717-721, October, 1926.
Downing, E. R.—Revised Norms for the Range of Information Test. School Science and Mathematics, 26:142-146, February, 1926.
Downing, E. R.—Norms for the Group Four Test. School Science and Mathematics, 26:638-643, June, 1926.
Ruch, G. M.—Tests and Measurements in High School Science, School Science and Mathematics, 23:885-899, December, 1923.
Ruch, G. M. and Popenie, H. F.—The Measurement of Ability in General Science. School Science and Mathematics, 23:543-551, June, 1923.

3 Downing has found that the correlation between scores on the Range of Information Test, which is somewhat subjective, with the scores on any one of the other three tests making up the Group Four Test, is higher than the correlation between the scores of any two of the objective tests.

formance of teachers from which we may infer the ability of teachers to meet successfully typical problematic situations in the teaching of general science. Let us turn our attention first to group No. 1.

The material for the Ruch-Popenoe test was obtained by the analysis of textbooks and the final selection of material was accomplished by means of the combined judgment of competent teachers. The material for the Powers test was also obtained by the analysis of textbooks in general science and of courses of study. The final selection was made partly as the result of trial in the classroom and partly by obtaining the concensus of teachers. Further evidence of the validity of the Powers test is furnished in the form of correlations of the test with teachers' marks, Regents' marks, and intelligence quotients. The material for the Dvorak Scales was gathered together from various sources. An item to remain in the scales was required to "satisfy one or more of the seven Cardinal Principles of Secondary Education." The material for Downing's test was also obtained from the analysis of high school science textbooks—not necessarily general science textbooks. In this way the important "conceptions of science" were discovered. The final selection was made on the basis of the concensus of opinion of twenty competent high school teachers. It may be well to note in passing that Downing's test is not necessarily a general science test but rather "a test in science in general."

Two forms are available for the Ruch-Popenoe test; two for the Powers test; three scales for the Dvorak test; and one form for the Downing test.

The following uses are given for these tests: (1) They may be of use in assigning marks; (2) They may be of use in determining promotions and failures; (3) They may be used in the classification of pupils into homogeneous groups; (4) They may be used in comparing the results of instruction in various localities; (5) They may be of use in school surveys; (6) They may be used to give the individual pupil an idea of his standing in the group; (7) They may be used in predicting the student's ability to go on into more advanced science; (8) They may be used to determine the relative preparation of pupils in the various sciences; (9) They may make the teacher aware of the individual differences present in any

3 Downing has found that the correlation between scores on the Range of Information test and one of the other three tests making up the Group Four Test, is higher than the correlation between the scores of any two of the objective tests.

class and thus enable the teacher to better adapt his instruction to these differences. Not every author has mentioned all of these uses but every use has been mentioned by at least one author. It is evident that the first six uses could not be accepted unless the objectives of the course under consideration are the same as the objectives implied by the test.

A step forward in test construction is made when specific objectives are set up for a specific course in general science; when the subject matter is scientifically selected in the light of these objectives; and, as the third step, tests are constructed to measure the performance of pupils from which performance of pupils one may judge the degree to which the objectives set up for the course have been realized. In this connection, we shall discuss two tests: (1) Toops "General Science Test";[4] and (2) "Tests on Everyday Problems in Science"[5] by Pieper and Beauchamp.

The Toops "General Science Test" was published in 1919. This test was not intended to be a comprehensive examination, but was "published rather for the purpose of illustrating the method" of constructing a test based upon the one word answer principle. Toops test is based upon Caldwell and Eikenberry's "General Science." The following are a few examples of the test items:

"What instrument is commonly used to measure the atmospheric pressure? *Barometer.*

"What astronomical body causes tides? *Moon.*

"Of what material is the positive pole of a dry battery made? *Carbon (C).*"

Dr. Toops writes in a personal letter that "we find . . . the scores on the examination indicate that the test has some considerable validity in spite of the fact that it has only 50 questions in it." "The one-word-answer type of test has higher reliability than the multiple choice form."[6]

In the judgment of the writer, this type of test has decided advantages when the objective is to test knowledge of subject matter. The outstanding contribution along this line, however, has been made by Pieper and Beauchamp.

In constructing their course of study in General Science—

4 Toops, Herbert A., "A General Science Test," School Science and Mathematics, 25:817-822, Nov. 1925.

5 Pieper, C. J. and Beauchamp, W. L., "Tests on Everyday Problems in Science," Scott, Forsman & Company, Chicago, Illinois.

6 Toops, H. A., "Trade Tests in Education," T. C. Contributions to Education, No. 115, 1921, pp. 39-54.

"Everyday Problems in Science"—seventeen major objectives for the course were decided upon and one unit was given over to the development of each major objective. These major objectives were expressed as important "understandings" of science rather than as knowledge of subject matter. Facts are important in the course but only as they contribute to the major understandings implied in the course. Each major understanding is usually analyzed into from 5 to 10 subordinate understandings — or problems — the mastery of which assures the mastery of the unit.

"Two types of tests are available for each of the seventeen units" of the course: "Factual Tests" and "Major Ideas Tests." For each type of test there are two forms. "The factual tests are designed to measure the pupil's knowledge of significant facts included in each Unit of the" course. The same form is used as that used by Toops, namely, the "one-word-answer." Two forms for each test are provided and each form has 50 test items.

"The Major Ideas Tests are designed to measure the pupil's understanding of the major ideas or conceptions of science and of the social implications of science studied within each unit." "Each test item is an incomplete statement concerning a major conception, followed by four clauses, phrases, or words which do or do not correctly complete the incorrect statement. The pupil indicates by a plus sign (+) or a minus sign (—) opposite each of the completions his judgment as to whether the completion is correct or incorrect." In this way every one of the completions must be judged either right or wrong. If a pupil judges correctly every one of the completions on a test item, it is assumed that he understands and he is given credit for the test item. All of the completions, however, must be correctly marked in order to receive credit for the test item. The following example will illustrate the type of test item employed in the "Major Ideas Tests":

"Fires are made

(a) by producing sufficient heat through friction to raise a material to its burning temperature.....( )
(b) by striking matches .....( )
(c) by the use of certain chemicals which produce heat when they combine .....( )
(d) whenever oxygen is brought in contact with a combustible material .....( )

These tests, by Pieper and Beauchamp, are objective, easy to score, and have norms established that may be used as bases for comparison. The following uses are given by the authors in the manual of directions: (1) The tests may be used "as one measure of accomplishment in the study of the Unit"; (2) The tests may be used "as a basis for diagnosis of deficiencies upon completion of the Unit"; (3) The tests may be used "as a basis for diagnosis before beginning the study of a Unit"; (4) The tests may be used "as a retest for those pupils who attain unacceptable scores on the first form at the close of the Unit"; (5) The tests may be used "as a test for pupils who may have been absent when the first test was given"; (6) The tests may be used "as a basis for determining local norms of accomplishment and using such norms for stimulating better work in succeeding classes."

In the judgment of the writer, these tests are a big step forward in that they are constructed to measure very definite objectives that have been previously set up, and that the "Major Ideas Tests" are constructed to measure the performance of pupils and, as a result of such performance, we are able to infer understanding of important scientific principles. The facts of science are now focused upon the understanding of principles. The next step in our curriculum construction will probably be the focusing of principles in just as definite a manner upon typical life situations.

One of the objectives for general science teaching that is often given is, "the development of the ability to use good methods of scientific thinking." Few teachers have actually gone far in the analysis of what is involved in teaching good methods of scientific thinking. In the writer's analyses of the questions found in textbooks and laboratory manuals in general science and in the laboratory manuals of high school chemistry,[7] very little evidence was found to indicate that textbook writers are at all conscious of what is involved in teaching good methods of scientific thinking. Scientific thinking is found in almost all lists of aims for general science teaching but comparatively little has actually been done to accomplish that aim.

7 Cunningham, Harry A., "Types of Thought Questions in General Science Text books and Laboratory Manuals," General Science Quarterly, 9:91-95, January, 1925.

Cunningham, Harry A., "Types of Thought Questions in Chemistry Laboratory Manuals," Journal of Chemical Education, 2:167-170, March, 1925.

Dr. E. R. Downing has just completed a tentative draft of a test which is designed to measure the performance of pupils from which performance the ability to employ the various steps in scientific thinking and to throw the necessary safeguards around each step may be inferred. This test is not, strictly speaking, a test in general science. It is, however, a test that is designed to get at an ability which general science teachers unanimously claim to be endeavoring to develop. The next step in this direction will likely be (1) the focusing of subject matter of general science upon typical problematic situations of life and (2) the development of tests to determine the pupil's ability to use good methods of scientific thinking in determining the proper activities in these typical life situations. The data that we have at hand indicates that it is entirely possible to teach good methods of scientific thinking. In this connection one would do well to read the very stimulating article by Dr. Downing in the March number of The Scientific Monthly.[8]

A very great number of specific abilities are needed in the study of general science. There is a very large field of opportunity for those who are interested in developing tests that will measure the performance of pupils from which one may infer the degree in which these various study abilities are present. Tests to measure both rate and comprehension in reading science material are needed. The Van Wagenen[9] Reading Scales are designed to measure ability in reading g neral science material. It is a test of comprehension. The data at hand indicate that these tests do "measure comprehension of scientific content printed in the English language when it is read silently . . . " and that they "should not be used to measure effectiveness of instruction."[10]

Vocabulary tests in general science are important. Any of the present science subjects has a special vocabulary to be mastered. General Science texts present a longer list of technical words than any other high-school subject.[11]

8 Downing, E. R., "The Elements and Safeguards of Scientific Thinking," The Scientific Monthly," 26:231-243, March, 1928.

9 Van Wagenen, M. J., "Van Wagenen Reading Scales," Public School Publishing Company, Bloomington, Illinois.

10 Broom, M. Eustace, "A Study of the Van Wagenen Reading Scales, General Science," School Science and Mathematics, 28:849-851, Nov. 1928.

11 Pressey, L. C., "The Determination of the Technical Vocabulary of School Subjects," School and Society, 20:91-96, July, 1924.

It would seem worth while to give some thought to the development of devices to measure: (1) effectiveness in oral and written expression in general science; (2) The rate of working; (3) Attention in studying general science material; (4) Number of reteachings necessary, etc.

Finally, let us consider briefly the importance of devising means of determining the extent to which teachers of general science are acquainted with the available data bearing upon the problems of general science teaching. We need to know also if general science teachers are able to apply the data at hand in the solution of their teaching problems. It was with the idea of making a little start in this direction that Dr. Douglas Waples and the writer devised a preliminary test entitled, "Classroom Procedure Test in Natural Science."[12] To make up the test, "ten typical classroom situations were selected from various lists of problems reported directly by teachers of high-school science and also from problems contained in professional literature on the teaching of science. The ten situations are described in separate paragraphs, each of which is followed by five possible ways of meeting the situation. The test consists in selecting that one of the five procedures that is best supported by experimental evidence and the one procedure most directly conflicting with such evidence." Two things were kept in mind in the final selection of the ten situations. On the one hand, situations were selected which represented activities that were found important and difficult in the "Commonwealth Fund, Teacher Training Study" conducted by Dr. W. W. Charters; and, on the other hand, situations were selected in connection with which there was some objective data available. At the bottom of each test, reference is made to the study or studies with reference to which the test is to be scored.

It is very difficult to discuss tests in general science without reference to the need of first determining in a scientific manner the general science curriculum. Our first step must be a complete statement of the aims and outcomes of instruction in general science. Our second step must be a scientific determination in the light of the objectives set up, of the course of study to be taught. Our third step may then very well be

12 Cunningham, Harry A. and Waples, Douglas, "Classroom Procedure Test in Natural Science," The University of Chicago Press, Chicago, Ill.

a design of tests and scales to measure the outcomes of instruction.

All will agree that the ultimate aim of general science teaching is to develop such abilities that will enable individuals to meet life situations successfully. The life situations with which teachers of general science are concerned are, of course, those situations that may be rationalized by an understanding of the principles of science. It is our business, then, to select from the large fields of human activities typical life situations upon which to focus our instruction. The objection will, of course, be raised that no two situations are exactly alike and therefore such a course is useless. It is true that no two situations are exactly alike but it also true that the problematic life situations may be classified into types and good methods of handling each type can be worked out. When typical problematic life situations are found upon which the subject matter of general science may be focused, we shall need tests which will determine the ability of pupils to react properly to these situations. In case they do not react properly to the situations set up, we shall need tests to determine whether the improper activity, in connection with the situation, is due to (1) lack of skill in scientific thinking, (2) lack of understanding of the principles of science involved, (3) lack of the skill needed to meet the situation successfully, or (4) lack of the proper ideals, or attitudes of mind, which are used as the final standards of conduct. When we come down to the specific classroom activities we find the pupil in need of various study abilities in order to carry on the classroom activities successfully. We need tests to help us determine the degree to which these various study abilities are possessed by the pupils.

Finally, through this entire process, we find the teacher continually facing problematic situations upon which the available scientific data must be focused. We must devise way and means of determining the extent to which teachers are acquainted with these scientific data and their ability to apply the findings of science to their teaching problems.

What Price Laboratory Instruction in High School Science[1]

RALPH K. WATKINS
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Two recent developments have seemed to indicate that laboratory instruction in high school science might be at least largely curtailed, if not perhaps abandoned. As a part of the modern movement for scientific and measured examination of our schools there has been an attempt at experimental evaluation of teaching procedures. It happens that a whole group of these experiments have contrasted the relative values of individual laboratory instruction and lecture-demonstration in high school science. This series of experiments seems to show that lecture-demonstration technique secures better immediate results than individual laboratory instruction. The second development has been the enormous increase in high school enrollments and the ever mounting costs of public education. These increasing costs lead us to scrutinize carefully any teaching procedure that is in itself expensive to conduct.

A third condition might also lead us to examine carefully the values of laboratory instruction in science. This condition has to do with the exact nature of the laboratory instruction that we actually find in operation in our schools. A careful scrutiny of the process as it is now carried on might lead the critic to question the general desirability of the process.

Much of the recent criticism of the science teaching in our high schools has resulted from the fact that the enrollment of pupils in the old established school sciences has failed to keep pace with the enormous increase in the high school in general. As a matter of fact if the period from 1890 to 1922 is used, the percentage of enrollment in the older school sciences has materially decreased. The new subject of general science is an exception to the rule in the general falling off of science enrollments. Science teachers, and educators in general, have been concerned with this decrease because of its contrast with the enormous increase, in our generation, in

1 Delivered at the annual luncheon of the "All Science" section of the Wisconsin State Teachers' Association, in Milwaukee, November 9, 1928.

the use of scientific applications and the interest evidenced in out-of-school popular science agencies. A whole generation of boys and men have gone radio mad. Popular science magazines and books have multiplied and been sold by the thousand. While this has been happening out of school, the percentage of enrollment of pupils in high school physics has been decreasing by approximately 40%.[2]

Laboratory instruction was introduced into high school sciences in the period between 1882 and 1890. The percentage of enrollments in high school physics, chemistry, geology, physical geography, botany, zoology and physiology have steadily decreased since 1895.[3] Enrollments have fallen in chemistry from 10% in 1890 to 7% in 1915 and remained at 7% in 1922. Enrollments in physics dropped from 22% in 1890 to 14% in 1915 and 7% in 1922. In physical geography the decrease has been from 24% in 1895 to 4% in 1922.

The fact that the period of forty years of widespread development of laboratory instruction has also been a period of apparent decline of interest in high school science may have no significance so far as causal relationship goes. It does present, however, a startling coincidence for the thoughtful science teacher. This coincidence becomes more spectacular when it is set side by side with another coincidence. The compensating increases in science enrollments of the last ten or fifteen years have been in general science, in which very much less formal and stereotyped laboratory instruction of the older sort has been attempted. Perhaps the actual loss of school science training to a large percentage of several school generations is the price of the kind of laboratory instruction which we have fixed upon our high schools.

This alarm about the status of natural sciences as school subjects has not set in motion the more immediate furore about laboratory instruction. This "viewing with alarm and concern" simply put science teachers in a more docile attitude when the attack came from another quarter.

Our modern attempts to reduce factors of the educative process to quantitative and measurable terms led to the attempt to evaluate in terms of measured results some of the teaching procedures in common use. The science teachers as believers

2 Cf. E. R. Downing, "Teaching Science in the Schools," p. 29.
3 Cf. Downing, Op. cit. p. 25.

in experimental verification soon attempted to apply the new investigational technique to their own teaching problems. It happened that a whole series of experiments comparing the relative merits of lecture-demonstration and individual laboratory instruction were carried on by different experimenters working in different parts of the country.

A group of these experiments was conducted by graduate students of Professor E. R. Downing. To this group belongs the work of Anibal, Cooprider and Cunningham. Other experiments carried on independently of this group are those of Wiley, Kiebler and Woody and Carpenter. The experiments were carried on in several of the fields of high school science, physics, chemistry, biology and general science and in different schools.

Any one of these experiments standing by itself presents relatively little cause for alarm to the proponents of laboratory instruction. Some are relatively crude judged by strict canons of scientific experiment. Class groups were in most cases small. The numbers in all except Carpenter's study were too small to permit accurate statistical treatment. The actual differences in data between the results of the two procedures are small. There is a question in most of the studies if the differences are larger than the probable error of the data.

Professor Downing has, however, summarized eight of these studies and they all come out in one way. Carpenter's study, done since this summarization, confirms the general result. All of the investigations are slightly in favor of the lecture-demonstration procedure *when immediate tests were given.* It is this unanimity of the series that supports the whole thesis.

In six of the experiments, retention tests were given after intervals varying from two weeks to five months. Again the results were all the same. For retention, all the experiments favored individual laboratory instruction. But again, the differences were small; although greater than the differences in favor of lecture-demonstration in the immediate tests.[4] Note that *none of these studies disprove the value of laboratory instruction* and that none of the experimenters are willing to advocate such abandonment on the strength of these experiments alone.

Since the widespread publication of summaries of these

4 Cf. Downing, op. cit. p. 122 ff.

studies, and others, a cloud of doubt has befogged the science teachers traditional belief in the value of laboratory instruction. Now, the taxpayers' dollar enters as the villain in the piece. If any difference in favor of laboratory instruction is small, why should people be asked to pay rather enormously for such a difference? Laboratory instruction is expensive in many ways. With double periods a single teacher can handle fewer classes. Equipment, furniture and floor space are expensive. Laboratory classes are usually small and costs per pupil are therefore high. School administrators in a day of rising costs are ready to welcome data which point the way to the reduction of equipment and instructional costs.

We are prone to think of modern educational problems in terms of the large city high school. The majority of high schools are yet small high schools in village situations. This is particularly true in the Middle West. Mr. John Harty, from the Northeast district of Missouri, has gathered a bit of pertinent data which throws additional light upon the laboratory-lecture-demonstration controversy from the point of view of the small high school.

Mr. Harty has gathered data from the high schools in the Northeast Teachers' College District of Missouri to show how much equipment is actually available for doing adequate individual laboratory work, especially in physics. Here are a few of the things that he has found:

1. Of 42 schools studied, 22 had no running water in science laboratories.
2. Only seven had science laboratories equipped with gas.
3. Nine had no source of electric current.
4. Only four had physics equipment valued at more than $500.
5. The value of laboratory furniture for physics ran from $32 to $570.
6. Amounts spent for new apparatus in twelve months varied from 0 to $520.
7. Fourteen schools spent $50 or less, twenty-eight $100 or less for new equipment.
8. Many schools were not equipped at all to perform one-fourth of standard experiments in physics.

If the facts discussed up to this point were the only ones involved it would seem common sense to recommend to teachers situated like those in Northeast Missouri that they invest their available funds in truly adequate demonstration equipment rather than to spread them thinly over inadequate laboratory equipment.

The whole story is not, however, so simple. It is very

probable that the experimenters so far have not been able to measure the more valuable outcomes of laboratory instruction. A number of critics of the available experiments have pointed this out. If the outcomes for pupils are of sufficient value, the added expense to secure these outcomes may always be justified. Just how valuable the laboratory experience as a whole may be we do not yet know. At least we do not know how valuable this experience could be made in terms of as yet unmeasured outcomes.

It is quite certain that the experimenters in evaluation of laboratory instruction have not paused to describe in any great detail the *kind* of laboratory instruction considered. Any critical evaluation of laboratory instruction must consider the nature of the laboratory work and the kind of product which it is assumed to produce. Just what do we expect laboratory instruction to accomplish?

Here are six or seven possibilities which may be suggested as general purposes for laboratory instruction in high school science:

1. The development of simple laboratory techniques, such as weighing, glass bending, microscopic manipulation, etc.
2. Proving and establishing for the pupil himself principles which have long since been well established and generally accepted.
3. Using the laboratory as an instrument for object or "thing" teaching according to the historical concepts of Pestalozzi, Commenius and Basedow.
4. Using the laboratory for the purpose of developing better understanding and interpretations of the principles of science, a means of better illustration.
5. To produce training in scientific method.
6. As a means of possible training in the experimental solution of the pupil's own problems.
7. The use of the laboratory as a workshop for the study of science problems which arise in the science class or in the life of the pupils.

Suppose that we consider for a moment the pros and cons of these purposes for laboratory instruction. It is doubtful if the majority of science teachers are conscious of any of them as they carry on the work in their laboratories from day to day. It is doubtful if we are adequately reaching any of them in most high school science laboratories as they are now conducted.

If the simpler types of laboratory techniques to be used in later high school or college science courses are to be the major aims of laboratory instruction then it would seem feasible to have much simpler laboratories with very much less

technical apparatus and less time-consuming schedules. More direct drill could be given in the processes of handling and manipulating materials and somewhat less upon scientific data and proof. Tests would need to be constructed to measure such techniques in order to determine the results of the work. Present studies other than a very suggestive one of Mr. H. H. Webb indicate nothing of what might happen.

Suppose that the major purpose of the high school laboratory is that of proving principles to the pupil's own satisfaction, objectification and illustration. It would seem on the face of the matter that a skilled demonstrator and illustrator, the science teacher, with satisfactory apparatus and diagramatic aids could do better than a very inexperienced illustrator, with poor apparatus and little or no skill, could do for himself. It would not seem to require ten years of experiment with educational methods to demonstrate this. This is what the series of available experiments do prove if they prove anything. Mr. Harty's picture of the apparatus available further substantiates this notion.

Present day psychology would indicate that there are scientific methods rather than a scientific method. The position could readily be defended that in all probabilities training in scientific methods is to be attained by the whole complex of the pupil's science training, rather than that part of it represented by the school laboratory. A case might also be made that any training in scientific method is impossible by the type of laboratory instruction prevalent in some of our schools. The pupil reads the statement of a principle in his text together with an illustrative experiment, and its accompanying data and conclusions. He goes into the laboratory with a manual which tells him what he is to find out and furnishes cook-book directions for each step in detail. He works with relatively crude apparatus to arrive at a conclusion or a set of data previously determined by a specialist with very refined apparatus. His own data misses the data given in the text or manual and he juggles his data to arrive at the data he knows he should have. And this is training in scientific method! What price laboratory instruction, indeed! If there is a lurking suspicion that such laboratories may produce training in scientific methods we must follow F. D. Curtis' lead and attempt

to produce tests that will measure such results, in terms of scientific attitudes and methods.

There remain of our proposed purposes the possible use of the school laboratory as a means of training high school pupils in the experimental solution of their own science problems and the use of the laboratory as a workshop for solving the problems that develop in science classes. This would seem to be the most promising of possibilities for laboratory instruction at the high school level. It is the very essence of the original reason for the existence of any laboratories at all, from that of the alchemist seeking to transmute base metals into gold to the modern research investigator seeking to split the atom, or even the lad in a corner of the basement trying to determine the effect of a new type of radio coil. In schools this type of laboratory is illustrated by some of the more advanced general science laboratories. Rarely have chemistry, physics or biology laboratories in senior high schools reached this stage. Just what the product of such laboratories would be in terms of outcomes for pupils we can conjecture.

In laboratories after this latter pattern trite illustrations or proofs of accepted theories and principles merely as laboratory busy work would be barred. Supplies would include much raw material. Some apparatus would be of the home-made pupil-constructed type. Little apparatus of the delicate and expensive kind would be provided except that needed for the teacher's demonstration work. Much use would be made of the apparatus in common use in the commercial world outside the school. The household gas and electric meters would find a place. So would such things as real telephones and radio, fire extinguishers and cameras. Use would be made of materials available in the community and in the homes of pupils.

In this laboratory, pupils would be in the main concerned with questions of application of principles rather than with the re-establishment of well known laws and principles. These established principles and facts would be accepted upon the basis of customary authorities and proofs as set forth and illustrated by the text, lecture demonstration, moving picture, everyday observation and so on. Problems of application which are acute in every community, in every group, and for

every individual, would be brought into the classroom, library and laboratory for solution. Such applications exist by the thousand for every established fact or principle.

Two illustrations of this will serve. It is well known that certain plants do not thrive in acid soil. The facts can be found in almost any good book on gardening. They may also be experimentally *demonstrated* by a clever teacher with quite simple apparatus. As a matter of fact pictures of plants with the different treatments might readily serve the purpose. The facts may be accepted and used. Suppose that I want to grow the plants in question in my garden. Will they do well in this particular plot? Is the soil sour? Of the materials actually available in my community which offer the best means of treatment? I do not know the answers to these questions, the teacher does not know, the author of the text does not know. I must attack the problem experimentally.

The general principles of good ventilation for households are known. These can be found in many texts. Good diagramatic illustrations abound. The particular physical laws can be demonstrated by relatively simple apparatus. I can learn, understand and readily accept these. But, I have a house with a particular furnace, located with reference to the plan of this peculiar house. It has so many windows and doors located according to its plan. It has particular shortcomings in provision for proper humidity. How can I plan a good scheme of ventilation for this house. I must apply my principles to this peculiar case. No one knows the result before this application is made. Parts of the proposed scheme require experimental proof before their success can be foretold. The whole requires a composite study of which experimental laboratory work might be a definite part and for these parts I could not crib any data which would suffice.

Would the laboratory described be worth while? Who knows? Such laboratories would need to be set up in schools. Their possible outcomes for pupils would need to be predicted. Tests to measure such outcomes would need to be set up and applied.

What price laboratory instruction? The price of laboratory instruction for the future lies in a careful scrutiny of the purposes of the school laboratory, the description and setting up of laboratories to fit the best of such purposes, and finally

the devising of tests to measure the true product in terms of the effects upon boys and girls. Only by such price may we justify the time, money, and possible waste. We should have laboratories not because our fathers have had them but because we can demonstrate that a particular type of laboratory can furnish definite and worth-while training to the boys and girls of the scientific today and tomorrow.

DO YOU KNOW?

1. That inside a circle having a diameter of 49 trillion miles, there is only one heavenly body which is hot enough to give out light and that body is our sun?
2. That *Betelgeuse* the bright star above Orion's belt is 300 times as large as the sun?
3. That Sirius is the most brilliant star we see in the sky?
4. That people living in the Southern Hemisphere of the earth cannot see the North Star, Polaris?
5. That a person weighing 160 pounds on the earth would weigh only 2 pounds on the moon?
6. That during the period from new to full moon we have a *waxing* moon; and from the full to the new moon it is called the *waning* moon?
7. That the earth is 3,000,000 miles nearer the sun in January than it is in July?
8. That because of its whirling motion the earth bulges slightly at the equator?
9. That there are other worlds in the process of making today?
10. That some astronomers think the earth and sun may be over a billion years old?

A Unit for Junior High School Science: Carpet Sweepers and Vacuum Cleaners

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This unit has been prepared to help teachers and pupils make use of devices in the home in connection with the regular school work. A vacuum cleaner should be available in the classroom for this lesson. Pupils are usually willing to bring devices from home if a vacuum cleaner is not a part of the laboratory equipment.

We are all interested in devices which help to make our work easier. The vacuum cleaner is one of the devices which has done much to reduce the drudgery in connection with cleaning our homes and it has made it possible to do the work better than it could be done with the broom or carpet sweeper.

Carpet Sweepers

The carpet sweeper came into use about 1880 and is still used in many homes to clean up odd spots on the carpets and rugs. It can be used to take bits of dirt from the surface of the rug, but it cannot remove much of the dust.

If you happen to have one of these carpet sweepers in your home you should examine it to see how it works. You will find it is necessary to move the sweeper back and forth in order to make it take up the dirt. Inside the case are brushes or brooms which are caused to rotate by the wheels.

Examine the wheels to see how they are connected to the brushes. What becomes of the dirt after it has been taken from the floor?

This type of cleaner you can readily see is an improvement over the broom.

What principles of science have been applied to make this kind of sweeper? Examine it for levers, pulleys and other devices. On a plain sheet of paper draw a vertical line in the middle of the page. In one column write the advantages of the carpet sweeper and in the other column the disadvantages.

For example, some people like it because it may be a little less trouble to use for cleaning a few crumbs or a little dirt from the rug.

In the list of disadvantages we might include the fact that it is difficult to clean in the corners with a carpet sweeper.

Try the carpet sweeper then complete your lists.

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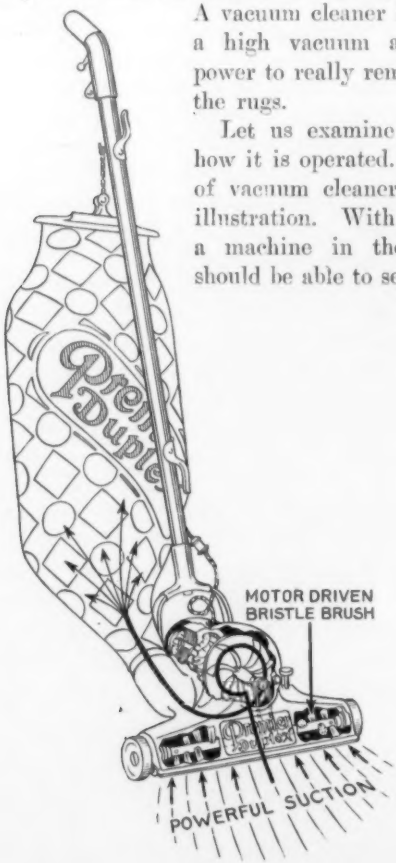
Osborne, F. A., *Physics of the Home;* University Book Store, University of Washington, Seattle, 1925, p. 65.

Whitman, Walter G., *Household Physics;* John Wiley & Sons, 1924, p. 343.

VACUUM CLEANERS AND SWEEPERS

Do you know the difference between a cleaner and a sweeper? The term sweeper is usually used for the machines which are operated by hand and the smaller electrically operated devices. A vacuum cleaner is a machine with a high vacuum and with enough power to really remove the dirt from the rugs.

Let us examine a cleaner to see how it is operated. A common type of vacuum cleaner is shown in the illustration. With this diagram and a machine in the classroom, you should be able to see how it works.



If you are not familiar with the meaning of air pressure you should turn to your general science textbook for help.

Place some bits of paper on the rug, start the motor and hold the cleaner over them. What happens? Can you explain?

In the illustration you can see the heavy line which indicates the direction of the air when the sweeper is operated.

When the fan is rotated rapidly it forces air into the bag and reduces the pressure in the cleaner near the floor. This gives us the name since a partial vacuum is produced.

The air pressure about the cleaner forces the dirt into the space with lower air pressure and on into the bag. The air goes on through the bag and the dirt remains.

Suggest a demonstration to illustrate the vacuum principle. This will not be difficult to do if you have an air pump in the classroom. A simple type of apparatus is shown in reference No. 1. p. 344.

The power of vacuum is shown by the experiment of Otto von Guericke in reference No. 2, Volume 4, p. 1245.

A test which shows the degree of vacuum can be made in your laboratory. Place a one-hole stopper in the entrance of the machine and connect to a manometer. Operate the cleaner and note the reading of the manometer. Reference No. 1, p. 344, will show you how to set up the apparatus.

With the large number of different makes on the market it will be helpful to make efficiency tests. These tests are described in reference No. 1, pp. 346-47.

Read the booklet on how to operate and care for a cleaner. Then make up a list of things to do in order to care for the machine properly.

Examine the attachments and learn their use. Connect them to the cleaner and try them.

In one column write the disadvantages of the vacuum cleaner and in another make a list of the advantages of using it.

In another lesson we may study the motor and the simple machines applied in this cleaner.

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1. Whitman, Walter G., *Household Physics*, John Wiley & Sons.
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The Growth of General Science in Boston

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It is a long way from "Darius Green and His Flying Machine" to the well developed Aviation Enterprise of today.

It is a long way from the candles, the pans, bottles and sundry dishes which formerly comprised the scientific outfit for the teaching of General Science, to the well equipped science class room with complete science outfit boxes of today; yet, the "Flying Machine of Darius Green" was but a fantasy: the Science Outfit boxes, but a dream. Fantasies become realities; dreams come true! But how! The absorbing power of a prescribed pabulum, usually tested by a written examination is not measurable by the same standards as is originality of thought. To be able to reproduce the words of others, or to shuffle mathematical symbols rapidly, may be creditable, but it is not to be compared with the power of originating ideas or devising new solutions of problems.

General Science has been taught as a subject in the Boston Schools for about fifteen years. In 1923, however, a new course of study was introduced. The new course of study consisted of fourteen pamphlets, each representing a teaching unit that had been tried out in actual practice and had proved successful. These pamphlets were the result of the work of twenty-four teachers, representing the High, Intermediate, and Elementary Schools with Mr. Joseph R. Lunt, Chairman.

When this new course of study was introduced it found the schools unprepared in equipment and without trained teachers for this subject. It was soon recognized that if science was to have a definite place in the course of study, proper equipment and materials must be provided and teachers trained to teach General Science. The child was the center of the educational storm. The realization that the child could not be fully prepared in these days unless he had some training in the type of science that surrounded him in his daily life, added stimulus to the work to be accomplished.

Through the cooperation of the Science Council and of the Schoolhouse Commission, each school was equipped with the

following:—science room, including table, gas, water, electricity and sufficient material — a minimum supply.

Realizing that the mastery of problems comes through effort the teachers of General Science, energetic, forward looking, sympathetic with the capacities and needs of the pupils, experimented, devised, originated, and exchanged ideas, especially in the courses in General Science to discover a better method of teaching the subject.

In 1925 the Experimental Outfits or Units for General Science were evolved. These outfits or units have proved most constructive in furthering the efficiency and effectiveness of science teaching in the Intermediate Schools. The units consist of cabinets or boxes that contain complete science equipment for demonstrating, together with pamphlets describing suitable experiments to be performed.

LIST OF UNITS FOR GENERAL SCIENCE COURSE, CITY OF BOSTON, FOR SEVENTH, EIGHTH, AND NINTH GRADES

An Experimental Course of Standard Units with Complete Equipment, Charts, and Special Apparatus

1. Air and Oxygen Outfit.
2. Carbon Dioxide Outfit.
3. Breathing and Ventilation Outfit.
4. Fuel and Fire Kindling Outfit.
5. Draft Control and Combustion Outfit.
6. Fire Prevention and Fire Extinguisher Outfit.
7. Heat Expansion and Conduction Outfit.
8. Convection and Radiation Outfit.
9. Hydrogen and Composition of Water Outfit.
10. Ice and Ice Water Outfit.
11. Steam and Boiling Water Outfit.
12. Density and Water Pressure Outfit.
13. Purification and Water Supply Outfit.
14. Temperature, Air Pressure, and Humidity Outfit.
15. Winds and Weather Observation Outfit.
16. Food, Diet, and Digestion Outfit.
17. Photosynthesis and Leaf Study Outfit.
18. Soil and Seed Germination Outfit.
19. Yeast and Molds Outfit.
20. Bacteria Outfit.
21. Planet and Solar System Outfit.
22. Constellation and Star Study Outfit.
23. Light, Spectrum Study, and Color Outfit.
24. Magnets and Magnetism Outfit.
25. Bells and Bell-wiring Outfit.
26. Cells, Storage Battery, and Electroplating Outfit.
27. Current Measurement and Control Outfit.
28. Electric Motor and Power Outfit.
29. Electric Generator and Transformer Outfit.

30. Electric Light and Heat Outfit.
31. Sound and Telephone Outfit.
32. Radio Crystal Receiver Outfit.
33. Radio Tuning Outfit.
34. Radio Vacuum-Tube Receiver Outfit.
35. Simple Machines Outfit.
36. Illuminating Gas Outfit.
37. Camera and Photography Outfit.
38. Textile Study and Clothing Outfit.
39. Light Measurement and Control Outfit.
40. Flower Study and Pollination Outfit.

These cabinets or units circulate in the schools under Mr. Lunt's direction. The cabinet, itself, has been perfected so that it is of a uniform, correct size, easily handled and durable.

The effect of these "magic boxes" on the pupils is that it arouses a real interest. I recently presented one of them in the following way. I placed the cabinet, closed, on the demonstration table and I called the attention of the pupils to the label on the box, it read "Magnets and Magnetism." We opened the cover to investigate: A holder on the inside of the cover contained the printed pamphlet giving the following outline:—

MAGNETS AND MAGNETISM OUTFIT

1. Study of a natural magnet.
2. Do magnets attract all materials?
3. To locate the poles of a magnet.
4. Does magnetism act through all materials?
5. To discover the laws of magnets.
6. How to make a steel magnet.
7. How to show the lines of force about magnets.
8. How a compass tells direction.
9. What is magnetism?
10. Is the earth a huge magnet?
11. To study magnetic field around a wire.
12. How to make an electromagnet.
13. How to increase the strength of an electromagnet.

Neatly packed inside the box we found the following materials and apparatus.

1 lodestone
1 pkg. iron filings
1 box carpet tacks
2 large bar magnets
1 horseshoe magnet
1 box articles to test magnetism: pieces of iron, steel, nickel, brass, glass, copper, lead, zinc, aluminum, paper, wood, rubber.
2 lbs. insulated copper wire
1 square cardboard, 10 in. square
1 tea strainer
1 alcohol lamp
1 set 4 in. square to test magnetism: glass, wood, cardboard, bakelite, iron, copper, brass, lead, zinc.
1 Black's magnet holder
6 steel strips
1 box pen points
4 dry cells
2 wire stirrups
1 spool thread
1 pks. darning needles
4 test tubes
4 cork stoppers

1 cake tin
2 lbs. paraffin
1 hammer
1 steel rod 18 in. long
1 set iron weights
1 magnetic needle on stand
1 pair pliers
1 push-button, mounted
1 helix stand
6 large iron spikes

The first paragraph of the pamphlet read as follows:

Magnetism is an important study, essential to an understanding of electricity. Magnetism produces electricity. Electricity produces magnetism. The two are inseparable. The compass needle is a magnet. The operation of electric bells, the telegraph, telephone receiver, loud speaker, electric motor, and dynamo depend upon magnetism. Electricity is generated in central power stations by powerful revolving electromagnets. Without magnetism we would be deprived of the convenience and comforts of electricity in our home.

Inside the box were mysterious looking packages. We opened each. We discussed in general the outline. We placed the packages in the box, closed the cover. This introductory lesson was a stimulus. Every lesson in the unit that followed was interesting, convincing, and had direct appeal to the boys and girls.

Some of the advantages of these boxes may be summarized as follows:

1. It saves time for the teacher.
2. The equipment is adequate and complete.
3. It makes for economy. Fewer pieces of apparatus are lost or broken.
4. The boxes keep the equipment clean and sanitary.
5. It makes possible a more flexible program.
6. It simplifies the taking of inventories and the ordering of new materials.
7. It eliminates unwise expenditure for unnecessary or useless equipment.
8. It provides for expansion and development, as new outfits may be added as occasion requires.
9. It encourages many teachers to undertake the teaching of science from the experimental standpoint.
10. It stimulates and holds the interest of the pupils.

General Science has won for itself a prominent place in the curriculum of the Boston Schools, due in large measure to the improved equipment and method made possible by the introduction of the "magic boxes." A few years ago these like the "Flying Machine" of Darius Green were but dreams, but dreams do come true. In this case "Right Science Training" was the keynote, with the interest of the child as an added incentive, all of which has resulted in establishing higher ideals in the teaching of General Science.

Wonderlands of Tomorrow[1]

Henry D. Hubbard

We have plenty of roads to Yesterday. We read of it in the morning paper and the morning mail; we study it in school and office; we view it on the stage and screen. We become yesterday-minded as we sit on the observation car of the world looking backward. Yesterday is the path our fathers trod, strewn with memories of achievement.

But what of Tomorrow? Tomorrow is the port toward which good ship "Earth" is sailing, the most fascinating port for which any traveller ever set sail. What do we know of Tomorrow? That it is a city of dreams! We are all building it, in Dreamland. Let us not underestimate Tomorrow. Science cancels the word "impossible" and with Bergson we begin to realize that nature is infinitely plastic, free to be shaped by a vision as clay in the hand of the potter.

Science predicts. That is its mission. Otherwise it cannot serve the world. Inventors predict. Their vision and skill are Tomorrow in the making. We all work for Tomorrow in all we do. A million things science predicts — sunspots, eclipses, tides, weather. But this is from knowledge. The dream has then just begun. Poet, prophet, dreamer, all dream the impossible, desirable thing, and after learned men show how impossible it is, the way opens to do it. Truer it is to say "All things are possible."

The stories of Jules Verne are being moved from the fiction to the science shelf in some of our libraries. Dreams become realities. His books should be printed in English to teach us vision and the delight in the dream. How many of Jules Verne's one hundred books have you read? Yet myth and magic and fiction are outstripped daily in the laboratory and factory. In our few minutes together we can glance at a few headlines, not because they are wonderful but because they are profoundly significant for the future of the race.

I venture to say that no scholar knows a thousandth part

1 A talk given by Dr. Hubbard (Assistant to the Director of the Bureau of Standards) at a banquet of the Society of Motion Picture Engineers. Reprinted from "Valve World," of January, 1928, by courtesy of Crane Company.

of modern discoveries or what they hold for tomorrow. Not only the stars are distant; but achievements all around us are a sealed book to most people, written in a foreign tongue—the mathematical equation, the chemical formula, the graphic curve. Yet science belongs to all the people. It is a racial heritage and its possibilities for tomorrow are without limit.

Automatic Machines

Today we have assurance that the automatic machine can do anything. We endow the automatic machines with creative power. Through them age-old crafts made perfect become immortal. Even power plants become automatic. The first automatic power-plant is in operation on the Peshtigo River in Wisconsin. Others are now at work cutting operating expenses down one half. The automatic power machine frees the human mind from repeat work. For a cent or two the machine gives us the equivalent of a man working a day. The human mind can turn to creating new things, the automatic machine to making them.

Fed with streams of material and power the factory pours forth streams of glorified things all surcharged with utility or delight. The factory is liberator. It manufactures emancipations. To it we send our tasks. It stands ready to absorb them all. Today we have the automatic machine. Tomorrow we shall have the automatic factory.

The factory speaks the language of creation; tools are its alphabet, machines its vocabulary, civilization its epic. Today we build the factory. Tomorrow the factory will make the world the paradise of our dreams.

What shall we all do then? I think we shall all do as Nietzsche said, think of nothing but education—the learning and telling, and enjoying both to the fullest of our capacity. Each of us will choose to do the thing we love best, with leisure, facility, opportunity to do it supremely well.

Synthetics

Illimitable vistas open up everywhere, notably in physics and chemistry. In comparison Alladin and Verne are tame today. The creation of new groups of atoms means a new era in human progress based upon the chemist's power to produce at will forms of matter and energy having any desired properties. The scepter of the material universe is being

handed to the scientist in the form of the data and technique born in the laboratory.

The chemist has created many thousands of new molecules, each unique in behavior and powers; like thein, which gently stimulates without intoxication; adrenalin, which duplicates nature's control of heart and lungs; like the complex iodine group, which controls body growth; atom arrangements, which reproduce the sweetness of sugar, the perfume of flowers, the color of their petals, the power to heal disease, to stir the heart to action, to relieve pain, or put the body into sound sleep. No written romance compares for thrilling interest with the story of chemistry in the service of man—a service which has just begun.

Farming and Food

Is it too early to experiment on large-scale indoor farming? A Belgian expert says it is time to turn farming over to the factory. Here every inch of soil could be sifted, made correct in texture and composition, freed of pests or injurious material. The air would be strained free of pests and kept at optimum temperature and humidity for finest quality of crop and greatest yield. No storm, drought, or frost could injure. Every crop would be a bonanza with never a failure. Radiation would be of the best quality ascertained by research, even the length of the shining day could be controlled. Fuel for heat, light, and power could be grown in this factory which would be a self-contained unit. Automatic machines would plant, cultivate, and harvest many crops a year. Future Burbanks would improve the stock by scientific seed selection, and by crossing, breed new varieties. Is not the experiment worth trying? We make great nurseries for plants, great factories for other products. Why not glass roofed units where the farm becomes an automatic factory, vastly increasing the yield, and with human labor completely eliminated except in supervision?

Manufacturing Food

Jacques Loeb once said that food may be made in the laboratory of the future, then in the factory, when we master the synthetic chemistry of food molecules. Now comes the word from France and from England that in the test tube at least the chemist has produced starch and sugar directly from the

air by the synthesis of moisture, carbon dioxide, and ultra-violet light of suitable wave length — Berthelot in France, Baly in England. Not yet in the factory, but some day, when the factory and farm become one, power-driven, continuous, starches and sugars may pour forth from the factory to feed the world. Man has solved the nitrate problem. Can he not assure the food supply of the world by placing it among staple factory products freed from the vicissitudes which beset the outdoor farmer? The way has been blazed and the pioneer successes give the promise of full success if faith and effort do not falter.

Climate

At your 1916 and 1921 meetings, I suggested to you the complete control of air conditions within the theater as a subject worthy your interest. It is technically possible today to reproduce indoors the famous climates of the world, or produce any conceivable climate. The production of climatic suggestion appropriate to the action of the film story may give us a new art. Why not climate anywhere. We have cold rooms for food, hot houses for plants, moist mills for cotton spinning, high pressure air for bridge building, low pressure rooms for motor tests. The air for our carbureter must pass through an air cleaner. We deodorize the air with ozone, cheer the sick with light and fragrance, and much more we do, bit by bit. The full vision of complete control must be set down in our every day thought and work its way to realization. Why not bring the best climates of the world into our living rooms and keep them there? No more the depressing heat, or the benumbing cold, the chill wetness, — or worse, the hot and humid days or nights. Eventually we must control every item of indoor weather every hour and every day by automatic machines, of course, simplified but effective. Research begins to disclose the many far-reaching results we may expect with ideal climate indoors for rest, work, or recreation. No greater factor in perfect health, working efficiency, and bodily comfort can be named than the complete control of indoor climate.

Aviation

Aviation came from the birds, actually from buzzards soaring over our national capital as photographed by Langley. We have left birds far behind in a quarter of a century. The

insects, however, still surpass us for speed and facile control. The incredible speed of the muscoid bot of the *cephenemyia* family, recently described in a scientific paper by Professor Townsend at 815 miles an hour is three times faster than the swiftest airflight. At such speed it could fly from Washington to San Francisco in four hours. The high speed motion picture camera alone will enable us to study the full secret of the almost bullet-like speed of this astounding fly.

We have hardly begun the serious motion picture study of the flight mechanism and flight control of fast flying insects—how they start, fly, steer, and land. The future art of aviation may find some of its greatest gains through trying out devices and control technique observed in some of the 300,000 varieties of insect life, some for low stalling speed, velocity; others for high speed.

With super-speed motion picture cameras we could slow down the screen picture in stereo relief to speeds most convenient for study.

Riding a Beam of Light

Fairy tales tell of riding a ray of light. We can do almost that with the new radio beacon devised by our Bureau of Standards. The flier rides on a slender ray of directed radio, like a search light beam, which guides the ship at sea or the plane in the air. The flier hears the letter "T" repeated intermittently when his craft rides straight the beam, and "N" or "A" when off course. A new device flashes a white light when on course and red or green when off course.

How simply the craft could be steered automatically by this silent invisible ray. The automatic power helmsman has already arrived, thanks to the gyrostat. A course can now be set in advance and the ship automatically and mechanically steers a true course. The automatic control of boat, plane, and car are as feasible as for stationary machinery. Can we not picture all travel by sea or air guided by such slender search-light beams of radio along lanes which automatically steer the flying craft on any predetermined course.

Radio Post

Our wonderful air mail is not the last word in high speed postal transmission. A greater system is in sight right here, transmitting letters by radio, reproducing them in facsimile

instantly at destination. No mail-bags, no sorting, no long trips overland! Swift as light, wired wireless or direct radio can produce at destination an autographic duplicate of a letter filed at the post office at Washington. Tomorrow, doubtless, radio post will deliver the world's correspondence instantly.

The world is alive with vision of the future of radio. The dream has awakened. Do you realize, however, that your own fellow member, the founder of this Society, is the man who not only had the vision, but the daring to attempt to unite the two most popular subjects, radio and motion pictures? With other public officials, I have seen his Dutch windmill running in Anacostia, shown on the screen in his laboratory near Dupont Circle. I am sure he will live to see radio vision a successful achievement.

May we ever hope for interplanetary transportation? The scientifically designed Goddard rocket answers "Yes, for export at least." The force of a series of rear-ward explosions drive the Goddard rocket at speeds which make it possible to leave the earth entirely. We may explore and study the upper atmosphere at first. Later we may shoot a Goddard rocket around the moon. We leave to the writers of fiction the suggestion that the rocket might contain a motion-picture camera set to operate as it passed around the daylight side of the moon. The return trip has already been described by Jules Verne in "Around the Moon." Let no one say that interplanetary communication is impossible. While radio as we know it does not pass through the upper atmosphere, perhaps the Martians are bombarding us with cosmic rays which readily penetrate not only the air but could pass through six feet of lead. Perhaps they think we are not yet sufficiently advanced in science to understand them, or perhaps they have given up the attempt as hopeless. Certainly the dreams of interplanetary communication may in time to come be realized as so many visionary projects of the past have today become realities.

Music

In the orthophone, music reaches a climax of mechanization for a single wavy line can portray a symphony concert, and a needle in a groove can reproduce that symphony. The vibraphone and saxophone give new types of tone qualities.

There are no outcasts in modern music. Jazz has removed all limits. Any tone is welcome or tolerated, the more so if bizarre or fantastic.

Science can produce all possible tone qualities without limit. Such is a supreme possibility now in sight, — an ultimate musical device producing any tone quality of existing instruments or of any possible instrument, and speech and song as well. Briefly, Fourier's mathematics, and electron tubes give us the means. Suitably paired these can be made to produce a harmonic series of beat tones, varied in pitch as the natural number sequence, 1, 2, 3, 4, and so on. Sounding together in due proportion these could produce all possible variations of wave form,—that is, every sound quality physically possible. The musical world would have for the first time a limitless range of tone qualities, including speech and song, in the form of radio waves ready to be amplified, broadcast, and reproduced with any intensity anywhere.

Immortal Youth

The Rockefeller Medical Institute has begun to master the technique of prolonging life indefinitely. For fourteen years a part of a chicken's heart has been kept alive, growing, and doubling its size every two days. We were shown recently the accelerated motion pictures of the growth of this tissue. The cells pushed out over the screen, jostling to find place, like a crowd gathering to view some great event. We were witnessing the growth of a living thing apart from its body. To prolong indefinitely the life of the heart of this chick is a first step in doing the same for the entire chick, then for higher organisms, perhaps eventually for man.

To perfect and keep youthful the human body by every resource science can reveal is man's supreme enterprise. To extend that life indefinitely — an age-old dream — is now a fascinating dream of present-day science. As Loeb told us, it is simply a matter of mastering laboratory technique through research, a marvelous example of which we saw on the screen.

A Last Word

My survey has touched a few topics. I have not spoken of motion pictures. For three days your minds have been filled with this most popular subject. In my talk at your

1921 meeting on "The Motion Picture of Tomorrow" I expressed my ideals for the year 1950 (or as much sooner as you choose). That talk still stands for my faith in the future of your art.

May I bespeak the omnipotence of the dream, the creative power of your vision, its importance as a subject for the motion pictures of tomorrow?

May it be for all of you a channel through which you may do for your children what your fathers have done for you; enrich the heritage. The dream made America great. It has created our modern science and life. It has scarcely begun to do for us what it can so easily do. Be proud of your dream. It is your intelligence in its highest flower. It is the instinctive foresight in every man. It is your best service to the world:

For the dreamer lives forever
While the toiler dies in a day.

Variety, The Spice of Testing

HANOR A. WEBB

George Peabody College for Teachers
Editor, "Current Science"

I. TESTS, KNOWN AND UNKNOWN

There have been certain persons—so rumor hath it—who enjoyed taking the long "essay" tests of pre-Glenn-and-Powers days of science teaching. There have been many—so experience confirms—who have received genuine pleasure in the marking, underlining, circling, X-ing, and checking of the intriguing "short-answer" tests. Both types of tests, however, possess a certain common characteristic that is not often mentioned in the meetings; each of them becomes exceedingly monotonous to students, particularly if administered rather frequently, with the prophylactic idea—the prevention, rather than the exposure of ignorance—uppermost.

Not every instructor knows how to put variety into teaching, much less into testing. For a considerable number of years a question has been put to classes of adults—science teachers both actual and prospective—that would permit data to be

given on the relative popularity, or the familiarity, of the better-known types of short-answer tests. In round numbers the results have been about as follows:

In a class of fifty—
50 knew the methods and principles of the "completion test";
50 understood the "true-false (or 'yes-no') test";
45 understood the "multiple-choice test";
30 understood the "range of information test";
10 understood the types of "matching tests";
10 understood the "relationship tests";
1 or 2 understood each of several other types of tests.

The average conception of the short-answer test, therefore, was that a certain form, or a few forms, comprised the whole matter. The broader comprehension of the short-answer test as a method seemed to be lacking. If the new type of testing is a method, or a plan, then ingenuity may be turned loose to give it many kinds of interesting forms; if the testing is itself a form, then a rigid adherence stifles the variety—and, by experience, the interest. We have witnessed real astonishment in the faces of some science teachers who had faithfully used three forms (you can guess which) of short-answer tests, when they were asked to invent a new form or two. They evidently felt that some super-intelligence—if not Glenn or Powers, then probably Ruch—had set these three up for their worship. The idea that they themselves could beget a plan was as weird as the centenarian Abraham was constrained to entertain; their protests were as earnest as those of Sarah.

II. A DOZEN TYPES TO BEGIN WITH

1. *The Completion Test.* This is too familiar to need extended illustration. Suppose the study topic be "Planets," the questions might begin thus:

(a) The farthest planet from the sun is .....

2. *The True-False Test.* (Certain frank persons call these "lies in cold print for children to study.") This type is as familiar as truth and falsehood. Suppose the topic be "Seasons," two questions might be as follows:

(a) The Spring Equinox is September 1st .....T....F....
(b) Winter begins December 21st .....T....F....

The "true-false" test may teach young pupils one important lesson—that approximately half you see in print isn't so.

3. *The Multiple-Choice Test.* (Gives the "guesser" a good chance, unless you know how to trick him out of it in the

grading," remarks an "old head.") The topic may be "New Textiles"; the question in this form:

(a) Celanese is (a breed of puppy) (a lustrous textile) (a Chinese food)

4. *The Range of Information Test.* ("The 'bluffer's delight," according to one who admitted checking 80% of the words on all such lists, letting the grader worry about the score.) A test most productive of argument over definitions —but here's the form:

(a) Check all words you understand or can define if (or is it *unless*) called upon: aileron, amphibian, bank, ceiling, drift, elevator, glider, fin, strut, taxi, pancake, loop, "give-her-the-gun." (Notice to grader: mark all answers wrong unless they apply to airplanes.)

This is really a good test, but will bear watching.

5. *Matching Tests.* There are several kinds of tests using the matching principle. Most familiar is the matching of words and phrases, which, in the topic "Famous Scientists," might be arranged thus:

(a) Number the words of (B) to match the phrases of (A).
(A) 1. Inventor of the telephone; 2. Author of "Sermons of a Chemist"; 3. Editor of "Science."
(B) .....Cattell; .....Bell; .....Slosson.

Not essentially different is the matching of phrases; a test upon several topics at once is readily handled thus:

(a) The sentences are divided in halves by semicolons; match the proper halves together.
(1) The ZRS-4 and the ZRS-5 are to be huge airships; they are smooth plains.
(2) (Colors may now be transmitted by television; the analysis of carbon dioxide is one accurate method.
(3) The "seas" upon the moon contain no water; they will each "swallow" five airplanes.
(4) Difficult housework may be measured chemically; a disc with three spirals is required.

6. *Classification Tests.* Some tests are primarily for use with small amounts of material; others are best employed with more comprehensive topics. More concisely—some types of tests could be used daily, while others should come at least a month apart. An example of the first sort is the "completion test," which, after all, could be given every few minutes during a class period, if the teacher were running a high temperature with the testing fever. The "classification tests" require a far greater interval for their crops of knowledge to grow before harvest.

The column form is usually convenient, and might start this way at the top of a page of tests:

(a) Rewrite these lists, placing each word in the proper column:

Words Related to			
airplanes	*radio*	*foods*	*clothing*
protein	grid	compass	stability
frequency	extracts	potential	fuselage
celanese	selvage	adulterant	mordant
etc.	etc.	etc.	etc.

7. *Misplaced Idea Test.* (Sometimes called "hide-and-seek test," though some pupils—and teachers—hide facts in the telling without trying to do so.) There is really a subtle art in making one of these tests; it is not enough merely to scatter the ideas around. The sentences should make apparent sense. Only teachers with a delicate touch in testing should use this often; crude work will show.

(a) The words in italics may be out of place, or they may not. Re-locate these words in their proper sentences.

(1) A group of stars in spiral form is called *an ameba.*

(2) Approximately *five thousand stars* are visible without a telescope.

(3) Luther Burbank was noted for *blackboard drawing.*

(4) *A galaxy* changes its shape in salty water.

(5) Elementary science students should practice *botanical research.*

8. *The 'Follow-Your-Leader Test.* This is based upon the method of certain "intelligence tests" that were used to determine the degree to which a prospective soldier could obey orders. In our experience this is the type the young people attack most eagerly. There is fun in it somewhere. In making it out, the teacher naturally works backward; this is a habit with some of us, anyhow.

1..... 2..... 3..... 4..... 5..... 6.....

Here are six spaces. If Lindbergh flew to Honolulu, put "N" in space 1; if he did not, put it in space 6.

If ultra-violet waves can be seen, put "E" in space 2; if not, put it in space 1.

If red "rainbow tubes" have helium in them, put "I" in space 3; if they are filled with air, do nothing.

If an automobile has traveled 350 miles per hour, put "Y" in space 2; if not, put it in space 4.

If fried potatoes are fairly digestible, put "O" in space 5; if not, do it anyhow.

If the engine in the "Spirit of St. Louis" has nine cylinders, rub out the letter in space 4, if one is there. If it is aircooled, put "D" in space 2, if not already full. If it is filled, do nothing.

If the spaces do not now spell the name of a scientist and inventor, take the last letter of the first name of an aviator and use it where needed.

9. *The Acrostic Test.* Even the ancient trick of the acrostic

lends itself to modern use in testing. This, after a study of electric light bulbs, might serve:

(a) Write the proper words in the spaces, making the first letter of each large and heavy. (We insert them in parenthesis.)

..(Nitrogen).... The principle gas in air, which must be exhausted from light bulbs.

..(Electricity)... A so-called "fluid" that passes through metallic conductors.

..(Oxygen)..... An important gas in air that must be completely removed from light bulbs.

..(Nitrogen).... A gas used to re-fill light bulbs of 50 watts and over.

The initial letters of this acrostic should spell the name of a gas used in the most recent types of electric illuminating bulbs and tubes.

This duplication of a word in this acrostic is a bit tricky, but tests—like "flappers"—are more interesting if they may be expected to do the unexpected. Tests should be piquant.

10-12. *The Rest of the Dozen.* Make them for yourself. We always leave something extra for our class to do. Use your own ingenuity; you may be very sure that the last of the test forms has not been brought forth. Pictures—thumb-nail sketches—will work happily in many combinations. "Recognition Tests" may use them with particular profit. You have seen the "missing part" idea tried with the littlest ones, of far greater advancement.

Are these various types of tests accurately graded? Not yet, so far as we have heard. Some day, someone will work out a highly accurate dissertation on the evaluation of the different types of short-answer tests. We will learn that one correct check in Type A is worth seven-fifths of a ring in Test B, nine-elevenths of an underscore in Test C, and six-thirteenths of a matched word in Test D. When we have this precise information available—oh, well!

III. LET THE CHILDREN MAKE THEM

For the first time, perhaps, in all the history of tests and testing, we have a kind of a test where the student may make it, and the teacher take it, with profit to both. We used to try this plan in connection with the "essay type" of test, but the results were rarely satisfactory. Students asked questions that either too simple or too involved; they were not good judges of value, or of the complexity of the information called for in an answer. Quite the opposite is true, however, as to the short-answer tests. The brighter pupils make them with all ease, and the others should learn how.

Any student who can construct an acceptable test in any of these forms, containing five or more parts, will have demonstrated a truer proof of understanding in connection with the study topic than if he had merely taken the test. This has been recognized by many ingenious teachers who, according to their reports in our classes, vary the plan in numerous ways. Having half the pupils make individual tests for the other half; having two pupils make one test for all the rest; having each pupil make one unit of a test, and select by committee study the best ten units; form pupil groups of five, with a "test-maker" assigned to each; these are but a few of the plans that alert teachers have been using.

Perhaps the best closing sentiment would be that honest confession of one teacher, who for years had been plodding along with the essay type of tests, doing all the work of making and grading as a matter of conscience:

"I've been an educational cook, not a teacher. I've dished and served—heaven knows how long, or how well. From henceforth I shall demand some service myself. What ho! children! My mind is hungry! Here is some raw stuff—prepare me some tasty tests!"

Laboratory vs. Demonstration — Are We Confusing the Issue?

W. J. KLOPP

Woodrow Wilson High School, Long Beach, California

I have just finished reading a recent study in one of the educational magazines, on the Comparison of the Lecture-Demonstration, Group Laboratory Experimentation and Individual Laboratory Experimentation Methods of Teaching High School Biology, in which the writer concludes, "Since the demonstration method, which at least held its own as a means to immediate learning, makes possible a considerable saving in apparatus and a very decided saving of pupil time, it may be able to more than offset any advantages that either of the other methods can offer."

His conclusion is based upon the comparison of the average scores made by small groups under these three methods, which comparison is to be justified by a ratio of the difference of the averages and the standard deviation of the difference of

the averages, and the ratios in every case except one is less than 2.0, making the ratios entirely without prognostic value.

I have reviewed more than a score of studies of this character, all of which attempt to establish a justification for the demonstration method in the laboratory sciences on the grounds of saving expenditures for equipment and time of the pupil.

If the laboratory sciences must justify their place in the high school on such a shallow basis, then there can be no reason why they should occupy any place at all. If the experimenter is trying to make an open confession that too much of the teacher's time, too much of the taxpayers' money, and too much of the pupil's energy is expended in this field of activity, then why not be honest and confess that there are no justifiable criteria for the teaching of any of the laboratory sciences.

Are we not confusing the issue? Is mastery of scientific content the true aim of the laboratory sciences? Is it the true function of the school to establish a minimum load for the teacher and a minimum cost for the taxpayer? Is it in harmony with the objectives of education for citizenship to determine the human values of a subject in terms of subject content mastery by some specific method employed by a teacher? I fear that we have reached a stage in our experimental research in which we confuse the true aims of science with the results obtained from a juggling of scores obtained from objective tests which test mastery of science elements alone. They do not test skills developed through well-organized laboratory procedure; they do not measure scientific attitudes created through the discovery and verification of truths; they fail to account for the many homely virtues accentuated while the pupil observes the rhythm and regularity and exactitude with which the laws of nature function; they can never fathom the depths of insight which stirs every impulse of his being as he experiences the results of his own creation. We have lost sight of the most fundamental objectives of the laboratory sciences, which is evidenced by the ever-increasing attempt to limit the activity of the child in an ever-changing situation. We appear to move toward a goal conceived only by the expert curriculum makers and the teachers, that of mastery of content, rather than that of development of character.

I am not unconscious of the fact that the university is re-

quiring a laboratory science for entrance into her courts, and that the high school must prepare for this event in accordance with the provisions laid down, and that failure to do so means lowering the standard of the school. But what of the multitude of children who are interested in science as it is related to life rather than its relation to college entrance? With 78% of the high school population of the country in school, of which less than 10% go to college, and less than 75% of those continue science, should we be so much concerned with that method which saves the teacher work and the taxpayer money, when there is such a need for leaders in our social structure who can think clearly, image vividly and act nobly; when we need men and women who are searching for the truth and finding it, will go out into life with a richer hope and firmer grip on what God intends for them to do? There is no field in the entire high school curriculum in which there is as rich an opportunity for the development of right social attitudes and right ideals than in the field of the laboratory sciences.

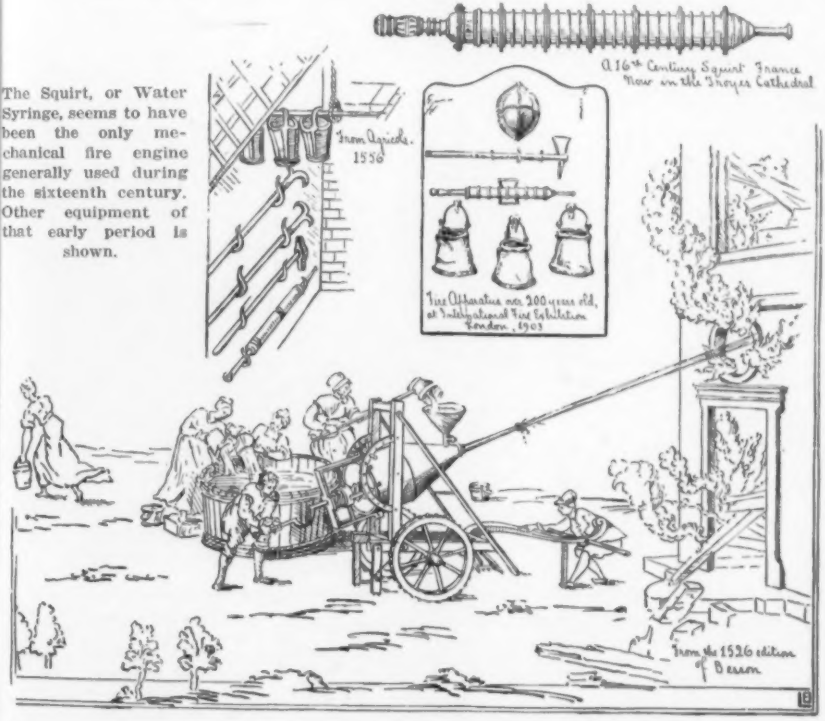
I do not mean to hide behind that much misinterpreted philosophy, "we learn to do by doing." I believe that the author of that philosophy had in mind that the "doing" must be both meaningful and purposeful. But I do want to emphasize the philosophical concept involved in the statement by Thorndike, that "you should learn to swim in water." The demonstration method may give the same results, so far as mastery is concerned, as the laboratory method, but if we could measure all the results of the experiences gained through actual contact with tools,—actual thrills obtained from successes realized by the child, and actual emotions aroused through self-functioning and self-realization,—then we would find the ratios between the differences of the average scores and the standard deviation of the difference to be unmistakably significant.

A War of the Centuries*

Dr. C. V. Tower

Drawings by Edna Hood Lissak

"Now, now indeed these nightly fires are sad," wrote Juvenal. So thought a bystander at one of those destructive fires by which ancient Rome was frequently visited. For, as he remarked to a companion — jingling the while a pouchful of golden solidi — with rents now so high in Rome one could make some very profitable investments, if there were any adequate fire protection.

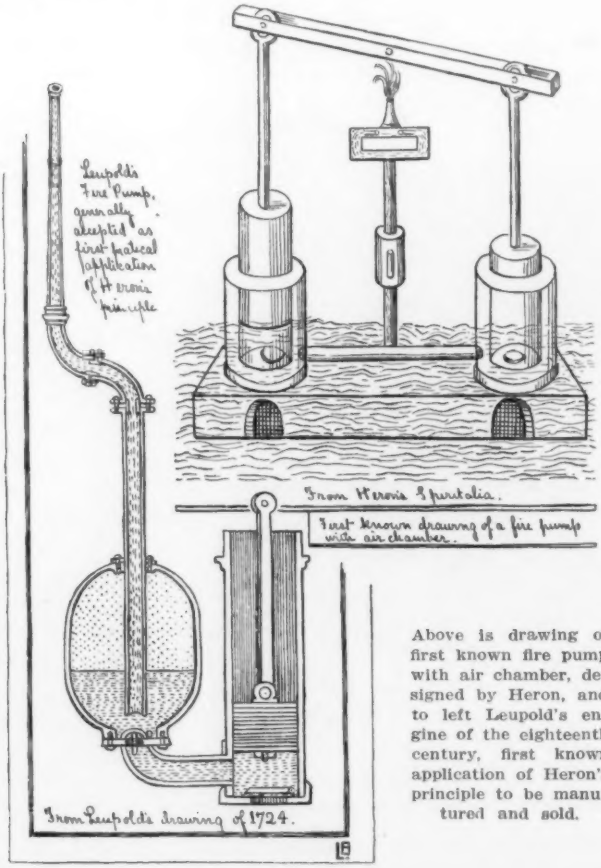


The Squirt, or Water Syringe, seems to have been the only mechanical fire engine generally used during the sixteenth century. Other equipment of that early period is shown.

This was in the days of Marcus Aurelius, whom history has consented to call "the Good" and "the Pious," notwithstanding some rather umbrageous activities in which he engaged.

* Reprinted from "Edison Monthly," Nov.-Dec. 1928, by courtesy of New York Edison Company.

But that is neither here nor there, the point being that as Gellius' bystander watched the flames spread from the tall lodging house and, leaping the narrow street, devour building after building, his thoughts were of man's ultimate conquest of an element that was to defy him for eighteen more centuries before steam, gasoline and electricity had achieved their control over it.


Leupold's Fire Pump, generally accepted as first practical application of Heron's principle
From Heron's Spiritalia.
First known drawing of a fire pump with air chamber.
From Leupold's drawing of 1724.

Above is drawing of first known fire pump with air chamber, designed by Heron, and to left Leupold's engine of the eighteenth century, first known application of Heron's principle to be manutured and sold.

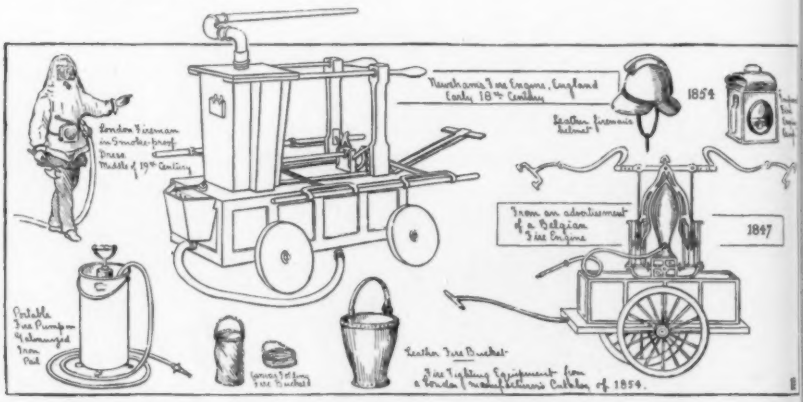
Little could be done in ages that were prone to refer all calamities to the contrivance of demons, or to dismiss them as "acts of God" against which the hand of man could not pre-

vail; when, if effort were made, the heralds' cry "To the water!" "To the water!" perforce did duty for the modern telegraphic signal; when buckets, ladders, hooked poles and siphons were the sole fire fighting apparatus, and exorcism and prayer seemed more efficacious than the busy futilities of existing fire brigades. Nevertheless, Rome had them — these fire brigades. About the year 6 A. D. Augustus called into being his seven cohorts of fire fighting policemen, combining, as it were, two municipal departments in one. Each cohort was under the control of a prefect and numbered a thousand men. They patrolled the streets by night, streets that were lighted only by their torches. Not a sufficient force, surely, for a city of nearly a million people as a deterrent of crime, to say nothing of protection against fire! Mighty conflagrations continued to be of frequent occurrence, and in one of these, which, in the year 37 A. D., destroyed large portions of the Aventine and contiguous Circus, the loss amounted to more than a million pounds. Rome's skyscrapers added to the danger until their height was rationally limited to sixty feet some time after Nero's costly display of pyromanic impulsion, but in most respects the situation was even worse in other cities. "The truth is," wrote Pliny, describing for the Emperor Trajan's benefit a "most destructive fire" in a provincial town, "the city is not furnished with either engines, buckets, or any single instrument proper to extinguish fires."

So there were engines of a sort!—no doubt the small siphons worked by hand. Long before, Otesibius had invented the force pump, but no effort had been made to render practicable Hero's conversion of the principle into a fire engine. The latter invention, the first known fire engine with an air chamber, dates possibly from the third century B. C. It consisted of two brass cylinders, when in operation partly immersed in water, connected with a discharge pipe, and accurately fitted with smoothly working pistons. Leupold's one-cylinder fire pump, an early eighteenth century invention, is the first known adaptation of Hero's principle.

Portable "fire engines" of the type later known as the "Squirt" are mentioned in the fourth century and again in the seventh, but "engine" was a blanket term covering anything with a suggestion of the mechanical about it, and their efficiency as fire fighters may be doubted.

The squirt reappeared in the sixteenth century and, in one form or another, was used until the beginning of the nineteenth century, when laws making it an offence to be unprovided with hand squirts were still unrepealed in England. The instrument was usually of brass and held from two to four quarts of water, the smaller squirt being about two and one-half feet long, with a half-inch nozzle. Three men were required to operate it, one on each side to hold the cylinder and nozzle (immersed in water), a third to pull back the piston and charge it.

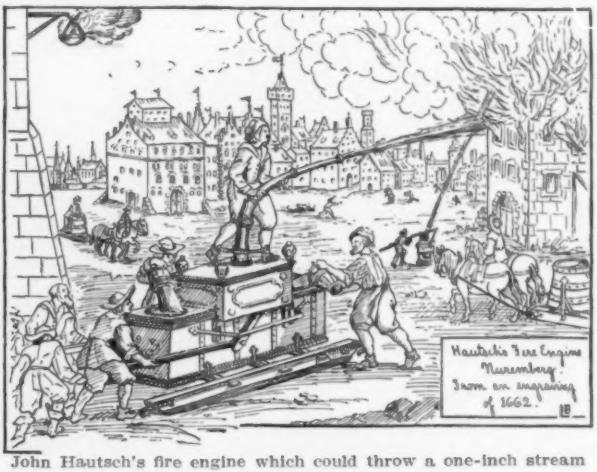

London Fireman in Smoke-proof Dress Middle of 19th Century
Newsham's Fire Engine, England Early 18th Century
1854
Leather Fireman's Helmet
From an advertisement of a Belgian Fire Engine
1847
Portable Fire Pump of Improved Iron Pail
Leather Fire Buckets
Fire Fighting Equipment from a London Manufacturer's Catalog of 1854.

Portable fire pump, folding fire buckets, helmet and lamp, from a London firm's illustrated catalog of 1854.

Besson's squirt must have seemed to the people of that day the last word in fire fighting apparatus, "for this kind of squirt may be made to hold a hoggeshed of water, or if you will a greater quantity thereof, and may be so placed on his frame, that with ease and small strength, it shall be mounted . . . and made to squirt out the water upon the fire that is to be quenched."

But Besson's squirt was not the crowning achievement after all, for in the next century improved fire apparatus was made in Holland, and in France, by special grant of "The Great King," Du Perrier (probably the first real fire chief) was empowered to build and supply engines of the new Dutch type. His firemen were resplendent in bonnets of royal blue with glided bronze fleur-de-lys, and manoeuvred their portable pumps and other fire equipment by whistle signals. Hautsch

of Nuremberg improved the hand engines of the period and built a large machine which was drawn by two horses and worked by twenty men. It was mounted on a sledge and threw water from a portable cistern to the height of eighty feet, which is to say, over the houses of the time. A capable machine no doubt! — unless one compares its performance with that of some powerful pumper of today, say New York's No. 65, with its 120 horse power motor and its four lines of hose, which pumps 1,100 gallons per minute and, when attached to standpipes, can force a stream of water fifty feet over the Woolworth tower.



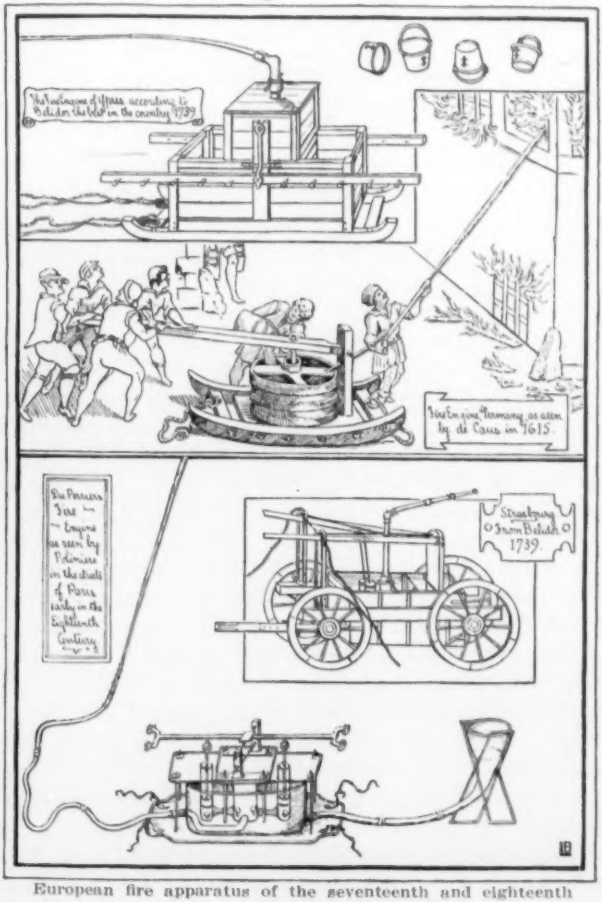
John Hautsch's fire engine which could throw a one-inch stream of water to the height of eighty feet.

At about the time that Du Perrier was making Paris safe for his master, Louis XIV, Newsham in England was at work upon a new type of engine, which, with modifications, was destined to retain the favor of firemen for a round hundred years. The engine was equipped with two pumps, worked by a double lever provided with long handles, augmented by the alternating application of foot power to the two treadles upon the box covering the pumps. In 1731 the Common Council of the City of New York ordered that two of these engines be procured from London "with all convenient speed," together "with Suction and Materials there unto belonging, for the Publick service." They were the first fire engines in America.

Washingtonians tell you that "nobody stays in Washington during the summer," yet there were sixty-five thousand people on the streets last September 3d — still summer, observe — to witness a Firemen's Parade which an inspired reporter described as "an iliad of the fire-fighter's art, unfolding in heroic fashion the story of his progress in battling against the ancient enemy." Engines, old and new, were there, from the diminutive double-piston, man-drawn and horse-drawn types of by-gone days to the huge self-propelled pumpers of the present. Of special interest as representative of the engines which succeeded those mentioned in the last issue of this magazine was a Centennial prize-winning steam fire-engine of Frederick, Md., "Lillie of the Swamp" by name, for the engine house of Frederick had been built upon the edge of a swamp and the men of Lillie's crew were known as "swampers." With its gleaming nickel-plated air chamber and brass smokestack the little engine appeared well cared for and presented a brave appearance after fifty years of service.

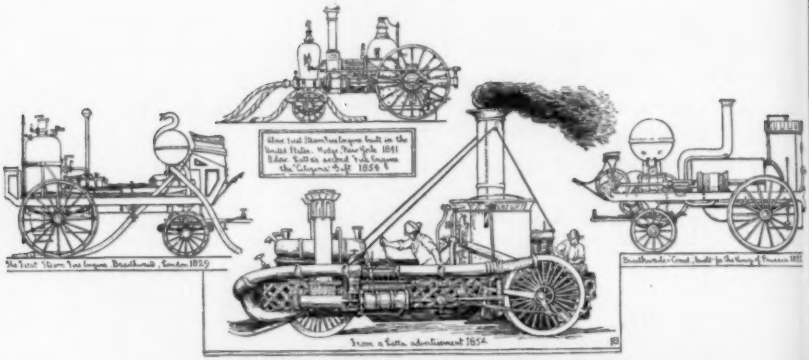
Long before Lillie's day steam fire engines had been in existence. As early as 1828 John Ericsson, best known as the inventor of the "Monitor," had designed the new fire-extinguisher, which he mounted on a rude carriage for experimental purposes, and his personal "claim to be the father of steam fire engines" is generally sustained. "The trials proved so satisfactory," said Ericsson himself, "that Mr. Braithwaite,

who built this first steam fire engine, decided to make another, to be mounted on a light frame suspended on springs suitable to run on pavement for practical purposes. I accordingly at once designed the second steam fire engine . . . the machine proving a perfect success on first trial." It was smaller than the first, but a more powerful pumper, throwing 168 gallons of water a minute to a height of 109 feet.



European fire apparatus of the seventeenth and eighteenth centuries

A third engine quickly followed, built for the Liverpool docks. Then came the "Comet," also designed by Ericsson

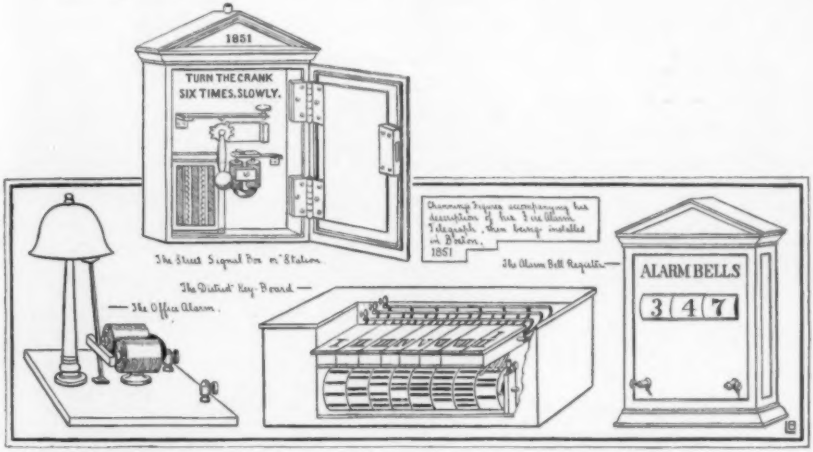


The forerunner of the modern steam pumper

and Braithwaite, Ericsson's partner, friend and patron. This was built for the King of Prussia, to be used for the protection of public buildings in Berlin, and the magazines of the day described it in terms which leave no doubt as to the favorable impression it made in England and Germany. It was a fifteen horsepower engine, weighing four tons, having two cylinders and two pumps of 10½ inch diameter, designed to work at 18 strokes a minute and in the same fraction of time deliver 304 gallons of water, ejecting the stream from its 1¼ inch nozzle to a vertical height of 120 feet, as proved by a public trial in England. A German newspaper of the time, commenting upon the arrival of this engine, says that with only an engineer, stoker, and one to four men to attend to the hose, "It saves the strength of 42 to 105 men, according to its size, from six to fifteen horsepower; it does not tire, works regularly and requires no relief." Men still spoke wonderingly about the new economies in an age that was not yet truly mechanical, and great must have been the satisfaction of the German Government at securing this marvel of mechanical ingenuity for the comparatively trifling sum of 1,200 pounds sterling.

Many were the difficulties and vexations encountered by builders of the early steam fire engines. The insurance companies were almost as bitterly opposed to steam as the Florentine doctors to the telescope of Galileo and the new pumpers at first found no favor with firemen. Braithwaite's first engine met with a cold reception from the London Fire Brigade and was hauled to fires without official connection with

that organization. In this country there was the same determined opposition to novelty, and the first steam fire engine of American manufacture, which was built in 1841 by Hodge, an English engineer, was rejected by the firemen and soon retired from service, though commissioned by the fire insurance companies.



Early types of fire-alarm boxes and transmitting equipment

But prejudice was not the only reason for this reluctance to adopt the new engines. Of course a steam pumper should be self-propelled and the early builders were unable to produce a satisfactory engine that would run to fires under its own steam until Latta built the "Uncle Joe Ross," a very heavy machine which was placed in service in the city of Cincinnati on January 1, 1853. But even this and other pumpers of similar type were usually drawn by horses, only a part of the propelling power being furnished by the engine itself. And here it is of interest to note that in the above named city and in the same year the first paid fire company was inaugurated. To Philadelphia, it may be added, belongs the distinction of having the oldest fire insurance company in America and the first fire association (1817) which grew out of the volunteer fire department of any city.

Latta's second steam fire engine is described as a "splendid machine" costing $10,000, a still larger amount having been raised by popular subscription to build and equip her. The

steam raising record of this engine was three minutes and 1½ seconds, and the machine threw a horizontal stream through a 2½ inch hose and 1½ inch nozzle to a distance of 297 feet, a truly remarkable record.

Fire towers and alarm bells

Steam fought fire for seventy years and not without stubborn resistance at the close of the century did the old steam fire engine at last give place to the new gasoline and electrically driven pumpers, predecessors of the efficient twentieth century engines of today. Gone are some of the well-remembered thrills of boyhood, the spark-emitting, smoke-belching red dragon of other days, more awe-inspiring to youth than the soaring flames it was designed to quench, but Efficiency recks not of thrills or boyish sentiment finding its worst foe in the prejudice which clings to that which is because it has been.

Probably the electrically driven pumper is less than thirty years old. The Sapeurs-Pompiers of Paris, a regiment of firemen of the French army, are credited with its introduction in 1899, and a first trial proved so satisfactory that a sum was appropriated by the municipality for the construction of five engines of similar type. In various cities of the United States electric engines have been put in operation. Eight of them may be seen in Camden, N. J., for example, and in Paterson the Fire Department is equipped with electric engines. In towns where traffic is heavy the electrically driven

machine seems indispensable, and the speed with which they get under way is one of the features to the advantage of this type of engine.

A modern fire engine, it was stated at a recent meeting of mechanical engineers, is "probably the most complicated piece of machinery that travels on four wheels," an assemblage that is mechanical from beginning to end, as such requiring the services of skilled engineers to pass upon its qualifications and performance. The engines of the present vary in pumping capacity from 300 to 1,500 gallons per minute. They carry more than a thousand feet of 2½-inch hose and, when provided with a chemical tank, additional one-inch hose for use at small fires. Severe tests at different pressures are required by the National Board of Underwriters "before a certain make or model of fire engine will be recognized," says a recent article, and "one engine of each model must successfully pass an endurance test of twelve hours under observation of Underwriters officials."

What Girl Scouts Should Know About Fire Prevention[1]

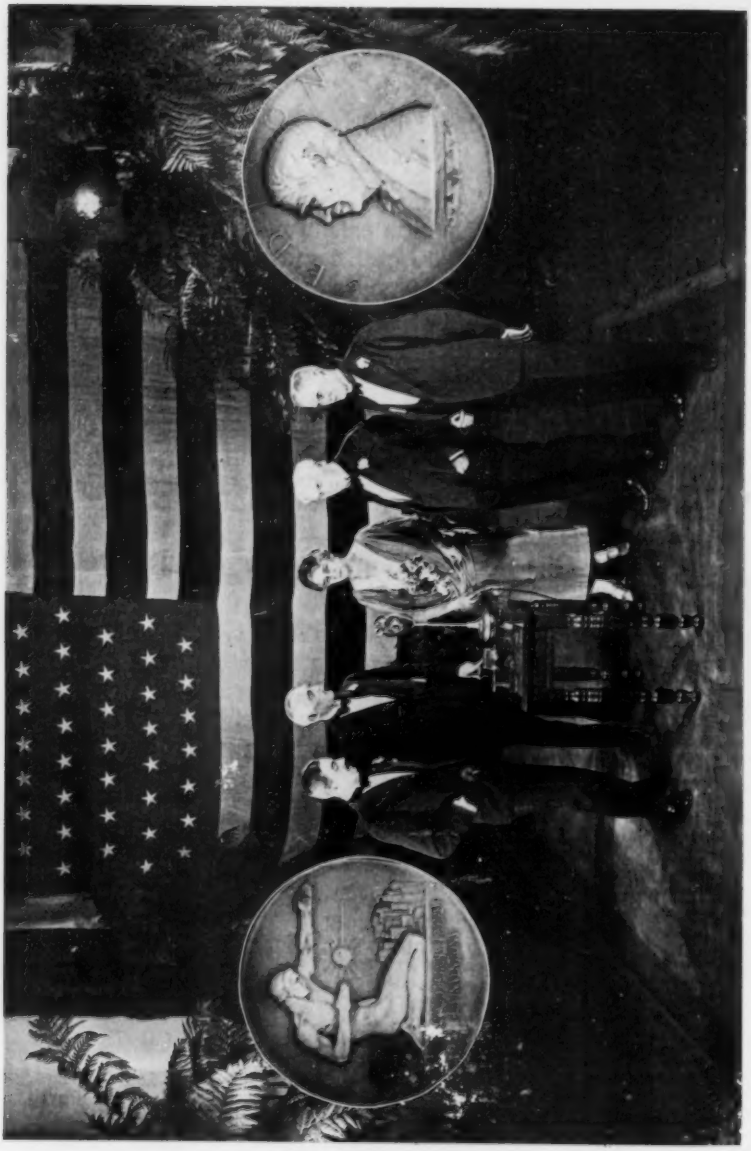
The subject of Fire Prevention is daily becoming of greater importance. People are recognizing the urgent need of practicing it and an increased effort is being made to spread the knowledge of preventive measure to all sections of the country.

A special effort is being made to impress this information on the minds of the younger generation. In conjunction with the leaders of the Girl Scouts the Insurance Department of the City of Jefferson, Missouri, conducted a Fire Prevention Campaign. Part of the program consisted of an examination for the Girl Scouts. These are the questions which were asked. How many can you answer?

1. What are the three main things mentioned in "Good Citizenship" which have to do with Fire Prevention?
2. (a) What is the most potent factor of human nature in the cause of destructive fires? (b) Name four ways in which this habit demonstrates itself.
3. (a) Give two safety rules for buying matches. (b) Give three safety rules for the use of matches.
4. (a) Give three safety rules for placing of stoves and furnaces. (b) Give three rules that should be observed in the use of stoves and furnaces.

1 From "Safeguarding America Against Fire," March, 1928.

(*Continued on page* 114)



The Nation Honors Edison on the Forty-ninth Anniversary of the Incandescent Lamp

On Saturday, October 20, 1928, Thomas A. Edison received the highest honor that the people of the United States can offer. Our government awarded him the Congressional Medal in recognition of his distinguished place among the world's greatest scientists and because of his numerous contributions to the welfare of mankind. The action of Congress was embodied in the following resolution:

"Under a Resolution of Congress approved May 29, 1928, the Secretary of the Treasury was authorized and directed to cause to be struck and presented to Thomas A. Edison a gold medal, with suitable emblems and inscriptions, in commemoration of the achievements of Mr. Edison 'in illuminating the path of progress through the development and application of inventions that have revolutionized civilization in the last century.' "

A small group was assembled in the Edison Laboratory at West Orange, where the medal was presented. The addresses were broadcast by radio, and President Coolidge spoke over the radio from the White House. President Coolidge's concluding words were: "Noble, kindly servant of the United States and benefactor of mankind, may you long be spared to continue your work and to inspire those who will carry forward your torch."

Honorable Andrew W. Mellon made the presentation address. Roland Ian Campbell, Chargé d'Affaires of the British Embassy, acting for Sir Esme Howard, the British Ambassador, officiated in the ceremony. Advantage of this occasion was taken to return to Mr. Edison his first phonograph, which had been loaned many years ago, to the South Kensington Museum in London.

In the picture opposite* are shown, from left to right, Mr. Campbell of the British Embassy, Mr. Mellon, Mrs. Edison, Mr. Edison, and President Hibben of Princeton. The inserts are photographs of the medal.

* Photograph used by courtesy of the New York Edison Company.

5. (a) Give three safety rules for open fires. (b) Give two safety rules for handling rubbish.

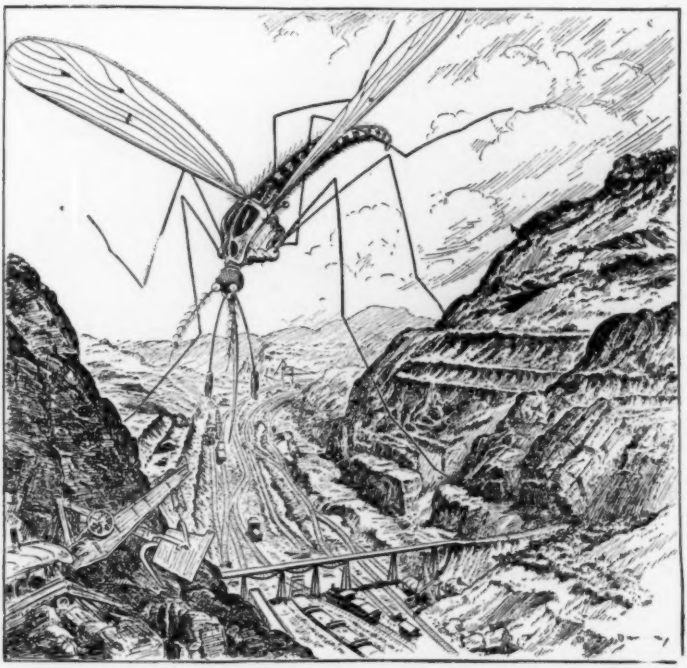
6. (a) When should you start a coal or wood fire with oil? (b) Should receptacles in which oil is burned be filled by daylight or after dark?

7. (a) What is one of the most dangerous volatile liquids in common use in the home? (b) Give four safety rules for its use.

8. (a) Why are "No Smoking" signs posted in various public buildings? (b) Give the New York Fire Prevention Bureau Law on the subject of smoking in factories.

9. (a) Name some of the articles made from celluloid? (b) Why do they present such a dangerous fire hazard? (c) What simple precaution renders them harmless?

10. Give safety rules to be observed in case of a serious fire.



The Mosquito Blocked the Way

Ask your students to write about the Panama Canal—the mosquito—Colonel Gorgas—and how the resources of science have brought together seemingly unrelated factors and made it possible to overcome great obstacles.

Water Power in the United States

The developed water power in the United States on January 1, 1928, was 12,296,000 horsepower, showing an increase of 576,000 horsepower, or approximately 5 per cent, during 1927; and the total amount of potential water power available 90 per cent of the time is 38,110,000 horsepower, and that available 50 per cent of the time is 59,166,000 horsepower, according to an announcement by the Department of the Interior, through the Geological Survey. The figures for potential water power are not directly comparable with the figures for developed water power, because the figures for developed power are given in terms of the capacity of the installed water-wheels, which may be several times the potential power available 90 per cent of the time. Estimates based on studies of the capacity of water-wheels installed at fully developed water-power sites indicate that about 15 per cent of the potential water power of the United States is developed at the present time. If it were feasible to develop all the water-power resources of the United States, the total capacity of water-wheels installed at all water-power plants would amount to about 85,000,000 horsepower.

All of the increase in developed water power in 1927 was in the plants of public-utility power companies, the capacity of water-wheels in manufacturing plants showing a small decrease during the year. California still ranks first in developed water power, with a total of 1,993,000 horsepower of water-wheels in water-power plants. New York, with 1,779,000 horsepower, is second, and Washington, with 707,000 horsepower, is third. The rest of the ten leading water-power states are all east of the Mississippi River.

The report from which these figures are taken contains tables showing the relative importance of the divisions of the United States in developed water power, the rank of the ten leading water-power states for several years, and the total amount of developed water power in each state on January 1, 1928.

The estimate of potential water power in the United States has been revised to include the results of recent studies and surveys, particularly in the upper Columbia River basin and the Tennessee River basin. Washington, with 11,200,00 horsepower available 50 per cent of the time, leads all the states in water-power resources by a wide margin. It is followed by California with 6,700,000 horsepower, Oregon with 5,900,000 horsepower, and New York with 5,000,000 horsepower, these figures representing power available 50 per cent of the time at an efficiency of 70 per cent. Most of the undeveloped power in New York is on the Niagara and St. Lawrence rivers.

Copies of the report giving by states the developed water power on January 1, 1928, and the estimated potential water power available 90 per cent of the time and 50 per cent of the time can be obtained by application to the Director, Geological Survey, Washington, D. C.

The New Books

Ten Years of Educational Research—1918-1927—Bulletin 42—College of Education, University of Illinois.

This is a paper-covered pamphlet of 367 pages, by Walter S. Monroe and Staff. The book treats: educational research before 1918; general survey of 1918-1927; research in educational measurement; curriculum research; reports of educational research; lists of doctors of philosophy in educational institutions, and a number of related tables. The price is $1.00.

Visual Instruction in the Public Schools—1928—Anna V. Dorris—481 pages—154 illustrations—$2.64—Ginn and Company.

Visual aids, though long used in education, have not been so abundant as they are today; and abundant as they are, few of us are making the best possible use of them. This book on visual instruction is opportune, and covers the whole field. It merits real study on the part of teachers and administrators. The book is divided into three parts: I. The background of visual instruction in modern educational procedure; II. Visual instruction applying to the teaching of the various subjects of the curriculum; III. Administrative problems of visual instruction in the public schools.

The book goes into detail in describing work that can be done in specific subjects, as history, geography, science, arts, health, reading, etc. The practical suggestions given are real helps and by heeding them much of our teaching will be improved.

The Book of Electricity—1928—Bertha M. Baker—314 pages—115 illustrations—92 cents—Houghton Mifflin Company.

This book gives useful information about electricity and electrical appliances; written in language easily understood by pupils in grades 6 to 8. It is not intended to take the place of lessons in elementary science, but rather to supplement them. It will, however, give valuable information to pupils in schools where science is not taught.

Elementary Engineering Laboratory Practice—1928—O. E. Edison and F. W. Norris—276 pages—121 illustrations—$2.80—Ginn and Company.

This book covers both D. C. and A. C. experiments for students in the electrical engineering power laboratory. More than eighty experiments are outlined. References and numerical problems are given.

Algebra—1928—Emery and Jeffs—626 pages—$1.85—D. Van Nostrand and Company.

We cannot imagine getting more material into a given space than has been done in this book. Teachers will find it a storehouse of interesting problem material with a unique organization.

Algebra Work Book—1928—Fowlkes and others—199 pages—80c—The Macmillan Company.

This book contains 100 drill tests. Each test is a single page with blank space for pupil's work. The pages are perforated. Blank space is provided for accuracy mark, speed mark, and average or test mark.

College Chemistry—1928—Neil E. Gordan—516 pages—88 illustrations—World Book Company.

This college text is particularly for those students who have had a high school course in chemistry. The prescribed material of the high school course has been omitted from this book, so that the student need not feel that he is covering familiar ground. This book helps solve the difficult problem of having in the same class those who have previously had chemistry and those who have not.

National Parks—Book II—1928—Mary Rolfe—329 pages—illustrated—Benjamin Sanborn & Co.

This is a fitting companion to Book I of the same name, and it is intensely interesting to read. The national parks covered in this volume are: Yosemite, General Grant, Hawaii, Lassen Volcano, Crater Lake, Mt. Rainier, Mt. McKinley, Glacier, Yellowstone, Wind Cave, Sully's Hill, and the proposed Grand Teton. Book I is suggested for the fifth and sixth grades; Book II for the sixth and seventh grades. They are well graded. A map on the inside covers shows the location of the parks.

Elementary Science Readers—Book III—1928—Payne-Barrows-Schmerber—172 pages—illustrated—Benjamin Sanborn & Co.

This reader covers subject-matter drawn from the field of chemistry and bacteriology. It is, of course, very elementary, as should be for Junior High School grades. It treats coal, petroleum, gases, metals, cement, glass, photography, drinking water, and smallpox; Pasteur, Lister, Trudeau and Walter Reed, and their works.

Elementary Science Readers—Book IV—1928—Payne-Barrows-Schmerber—197 pages—illustrated—Benjamin Sanborn & Co.

This fourth book in the series of Science Readers treats the physiographic features of the earth, such as the earth's crust, ocean waves, inland waters, earthquakes, volcanoes, and glaciers. Man and his effort to make adjustments to the earth is given prominence. The whole series give interesting worth-while material which is good for supplementing a course in elementary general science.

Nature Study and Health Education—for third year—1928—Alice J. Patterson—184 pages—illustrated—McKnight and McKnight.

This book offers a variety of material seasonally arranged for nature study in the third grade. It also offers a variety of methods in teaching. Some lessons are observational, others conversational, and others make use of projects. Health lessons are interwoven with nature study in places where direct relations are strongest.

Notebook for Nature Study and Health Education—1928—A. J. Patterson—96 pages—McKnight and McKnight.

This is a pupils' manual to accompany author's text, and includes blank forms for pupils to fill in and blank spaces for appropriate pictures. Some drawings are suggested.

A Tale of Soap and Water—1928—Grace T. Hallock—96 pages—illustrated—paper covers—a limited number free for school use—School Department, Cleanliness Institute, 45 East 17th St., N. Y. C.

A real masterpiece on the historical progress in cleanliness. It was written for seventh, eighth and ninth grades, and even grown-ups will read it through once they start.

The Animal Way—1928—Jean Broadhurst—64 pages—illustrated—paper covers—one book free to each of kindergarten, 1st and 2nd grades—additional copies, 25 cents each—$20.00 per 100—School Department, Cleanliness Institute, 45 East 17th St., N. Y. C.

A picture book with animal keep-clean stories. The large, full-page, colored pictures lack the proper animal to complete it, but space is left for it. This animal the child finds in another part of the book, cuts it out, and pastes it in the proper place. This will delight the younger children.

Charts for Civics, Geography, Arithmetic, and General Science—1928—Fay Campbell—96 pages—illustrated—Wheeler Publishing Company, Chicago.

Suggestions are given for making various types of charts or graphs to show data of different kinds. Some of these will be helpful in a part of the general science work.

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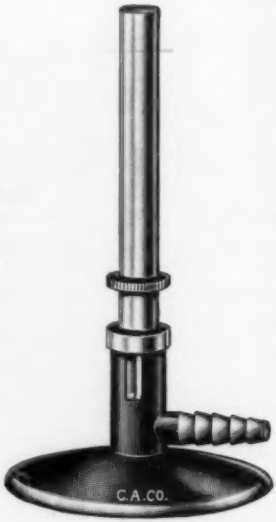

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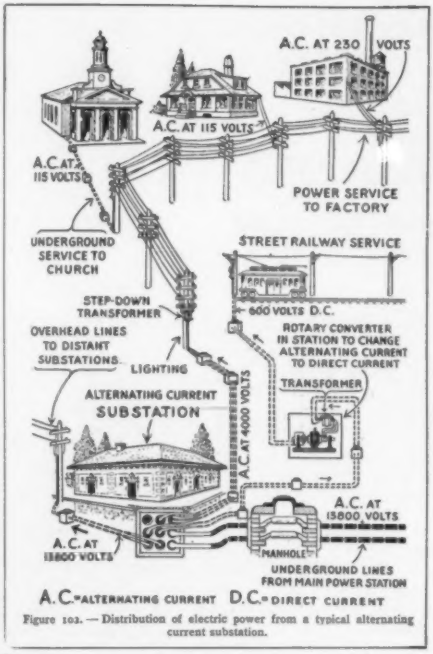

Figure 102. — Distribution of electric power from a typical alternating current substation.

This is one of the many excellent diagrams which are a notable feature of

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By JOSEPH R. LUNT
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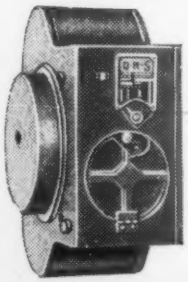

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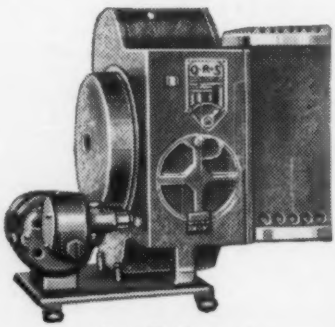

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